SOCIETY FOR THE

PROMOTION OF AGRICULTURAL SCIENCE

PROCEEDINGS

OF THE

THIRTY-SECOND ANNUAL MEETING

COLUMBUS, OHIO, NOVEMBER 13 AND 14, 1911

PUBLISHED BY THE SOCIETY
1912

Proceedings

OF THE

Thirty-second Annual Meeting

OF THE

Society for the Promotion

OF

AGRICULTURAL SCIENCE

HELD AT

Columbus, Ohio

November 13 and 14, 1911

Edited by the Secretary

E. W. ALLEN

Published by the Society

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The Columbus Meeting, 1911.

By E. W. Allen,
Secretary-Treasurer.

The thirty-second annual meeting of the Society was held at Ohio State University, Columbus, Ohio, November 13 and 14, 1911, immediately preceding the annual convention of the Association of American Agricultural Colleges and Experiment Stations.

By special arrangement several other agricultural societies, among them the American Society of Agronomy, the American Society of Animal Nutrition, and the American Farm Management Association, held their meetings at the same time, which added to the success of the gathering, as a large number of persons interested in the progress of agricultural science were thus brought together. This called for some adjustment of programs between the secretaries of the various societies, to avoid unnecessary conflict, and permitted the holding of three joint sessions, which were occasions of unusual interest. These were announced on the programs of the various societies, and the subjects selected for these meetings were of broad interest, so that the attendance was large and representative of the various branches of agricultural science and experimentation.

The first of these general sessions was held on Monday evening, November 13, for the presentation of the presidential addresses of Prof. S. M. Tracy, of the Society for the Promotion of Agricultural Science, on Governmental Promotion of Agricultural Science (see p. 11), and Dr. H. J. Wheeler, of the American Society of Agronomy, on The Status and Future of American Agronomy. Dr. H. P. Armsby, of Pennsylvania, presided at this session.

The retiring address of Dr. H. P. Armsby as president of the American Society of Animal Nutrition was given in the afternoon, and while the session was not a joint one it was attended by many visiting members from the other societies. The subject of the address was Some Unsolved Problems, and it was an admirable presentation of some of the present weaknesses of American fedeing experiments, with suggestions for

investigations and experiments which should contribute to the further knowledge and understanding of animal feeding.

The second joint session was held on Tuesday afternoon, November 14, and was devoted to a symposium upon Improvement in Methods of Agricultural Investigation, participated in by representatives from the Society for the Promotion of Agricultural Science, the American Society of Agronomy, the American Society of Animal Nutrition, and the American Farm Management Association. There were five speakers, and the papers were specially prepared for the occasion. Dr. A. C. True, of the Office of Experiment Stations, followed by Prof. S. M. Tracy, presided at this session.

On the evening of November 14 a third joint session was held of the four societies named above, to consider the general subject, What is Farm Management and What Will Be Its Contribution to Agriculture? This program was largely in the hands of the American Farm Management Association, although participated in by representatives from the various societies. The presiding officer was Dr. Thomas F. Hunt, of Pennsylvania.

The only separate session of the Society for the Promotion of Agricultural Science was held Tuesday morning, November 14, with the presentation of six papers. These papers, together with the papers delivered by representatives of the Society in the symposium, are given in the following pages.

BUSINESS MEETING.

The secretary reported that during the year the Society had lost six members by resignation and three by death. These three were: Prof. F. H. King, of Wisconsin, and Dr. E. B. Voorhees, of New Jersey, regular members, and Dr. Oskar Kellner, of Möckern, Germany, an honorary member. During the year thirteen members elected at the previous meeting accepted membership, making the total enrolment at the time of the meeting one hundred and sixteen regular members and one honorary member.

At the meeting the names of twenty-two candidates for membership were presented and approved, all of whom subsequently accepted membership. This list of new members is as follows: Dr. W. H. Dalrymple, Veterinarian, Louisiana

College and Station; Prof. W. R. Dodson, Director, Louisiana Experiment Stations; Prof. M. L. Fisher, Crop Production, Indiana College and Station; Dr. G. S. Fraps, Chemist, Texas College and Station; Prof. Arthur Goss, Director, Indiana Experiment Station; Prof. E. B. Hart, Chemist, Wisconsin College and Station; Prof. Harry Hayward, Director, Delaware Experiment Station; Prof. H. G. Knight, Director, Wyoming Experiment Station; Prof. F. B. Linfield, Director, Montana Experiment Station; Prof. E. R. Lloyd, Director, Mississippi Experiment Station; Dr. Charles A. Lory, President, State Agricultural College of Colorado; Prof. A. G. McCall, Agronomist, Ohio State University; Dr. C. E. Marshall, Scientific Director, Michigan Experiment Station; Prof. F. R. Marshall, Animal Husbandman, Ohio State University; Mr. D. W. May, Special Agent in Charge of Porto Rico Experiment Station; Prof. F. W. Morse, Research Chemist, Massachusetts Experiment Station; Mr. George M. Rommel, Chief Division of Animal Husbandry, U. S. Department of Agriculture; Dr. F. L. Stevens, Dean, College of Agriculture, University of Porto Rico; Prof. R. W. Thatcher, Director, Washington Experiment Station; Dr. John A. Widtsoe, President, Agricultural College of Utah; Prof. W. A. Withers, Chemist, North Carolina College and Station, and Mr. B. Youngblood, Director, Texas Experiment Station.

This brings the list of regular members up to one hundred and thirty-eight.

The treasurer's report, submitted by E. W. Allen, was as follows:

Report of Treasurer from November 15, 1910, to November 14, 1911.

Balance due former Treasurer, November 15, 1910		$35.02
Balance due Custodian, November 15, 1910		6.14
Membership fees collected by F. W. Rane	$96.00	......
Membership fees collected by E. W. Allen	226.20	......
Postage and outstanding bills paid by F. W. Rane after close of year	......	10.50
Printing and mailing Proceedings of 1910	......	172.35
Printing circulars and programs	......	8.75
Letter heads and receipt book	......	2.35
Postage and postal card announcements	......	13.78
Express charges	......	.85
Balance on hand November 14, 1911	......	72.46
	$322.20	$322.20

This account was audited and reported correct by Dr. H. P. Armsby and Dr. W. P. Brooks.

The financial report of the assistant custodian, Prof. W. D. Hurd, was as follows:

Report of Assistant Custodian.

Receipts from sale of Proceedings:			
Ontario Agricultural College	$15.00		
New Hampshire State College	7.50		
Maryland Agricultural College	15.00		
Virginia Experiment Station	15.00		
North Carolina Experiment Station	15.00		
University of Missouri	2.72		
New York Experiment Station	2.15		
South Dakota State College	15.00		
University of Minnesota	15.00		
Washington State College	15.00		
Ohio Experiment Station	15.50		
		$132.87	
Cash received from Dr. W. J. Beal, custodian		11.25	
Postage for mailing announcements of sale of reports		......	$1.20
Express		......	.35
Trucking reports		......	.25
One padlock		......	.25
One record book		......	.35
Balance on hand		......	141.72
		$144.12	$144.12

On the outstanding accounts, bills receivable amounting to $36.99, and bills payable amounting to $8.53 were reported, making an additional balance due the Society of $28.46. During the year one hundred and nine volumes of the Proceedings were sold at fifty cents each, and thirty-five volumes at $1.00 each, the prices fixed by the Society at the preceding meeting. An inventory submitted with the report showed that the assistant custodian had on hand 5,263 copies of the Society's Proceedings, which at the prices fixed would have a total value of $2,693.50.

The secretary reported that during the year an invitation had been received from the American Year Book Corporation, inviting the Society to cooperate with a large number of other learned societies in the preparation of material for the Year Book, and to designate a representative on the supervisory

board. It was noted in the invitation that the Society had been selected as standing for agricultural science in this country, and the list of constituent societies was plainly such as to give character and standing to the undertaking. After correspondence with the president of the Society, the secretary had been designated to represent it *ad interim*, and the matter was laid before the Society with reference to formal action on its part. The Society voted to accept the invitation to become one of the constituent societies, and designated the secretary, E. W. Allen, to act as its representative, authorizing the attendance on such meetings as might be necessary.

The Society voted to join the Affiliated Societies of Agricultural Science, and designated E. W. Allen to act as its representative on the council for a period of two years. The dues for the year were continued at $2.00, with the possibility that funds might be needed in furthering the new affiliation.

A communication was received from Dr. L. O. Howard, the American member of the International Commission of Agriculture, under whose auspices several international congresses of agriculture have been held, and which has effected a permanent organization with headquarters at Paris. This commission is composed of representatives of agricultural associations and government officials from different countries, and is supported by contributions from the associations. An invitation was extended to the Society to contribute $5.00 a year to this work, which would not only enroll it among the national societies promoting the movement for international congresses of agriculture, but entitle it to send delegates and to receive the publications of the commission. The Society voted to join the commission and to contribute the sum mentioned annually.

Dr. W. J. Beal, custodian, reported upon the generous provision made by the Massachusetts Agricultural College for the safe storage of the Proceedings of the Society, which have now been turned over to the assistant custodian. The college has been to considerable expense in installing shelving and making other suitable arrangements, and it was proposed that in view of this a set of the Proceedings be donated to the college library. This proposal met with favor, and was unanimously agreed to.

As a result of the postal card ballot the following officers were declared elected for the ensuing year: President, Dean E. Davenport, Urbana, Ill.; secretary-treasurer, E. W. Allen, Washington, D. C.; members of the executive committee, W. H. Jordan, Geneva, N. Y.; H. P. Armsby, State College, Pa.; and H. L. Russell, Madison, Wis.

Governmental Promotion of Agricultural Science.

PRESIDENT'S ADDRESS.

By S. M. Tracy,
Special Agent, U. S. Department of Agriculture.

A year ago, when you honored me with this position, I used the opportunity to present something of the results of my own investigations. To-night, however, I have no startling discoveries of my own to announce; and you, many of you who have been my fellow-workers for a third of a century, do not need to be reminded of what this Association has accomplished, or to have problems suggested for future consideration.

Our Association is a group of individuals each one of whom is working for the promotion of the science of agriculture. All new ideas, all new thoughts, all discoveries of new laws and new principles, are the result of individual effort—of the work, the study, and the research of the individual student. Ideas are personal and individual before they can be communistic. The individual investigator must always stand first, but his work cannot always reach the highest plane and cannot always cover the broadest ground if he must work alone; if he cannot have the help and cooperation of others.

I want to use the time given me to-night to say something of what the government, both state and national, is doing to assist individual workers in the promotion of agricultural science. Lincoln, in his immortal speech at Gettysburg, spoke of the ideal government as being one "for the people." It is "for the people" that our own government is now giving so much of its best work to the solution of the many practical problems which confront the farmer, the man on whom "the people," and the very government itself, depend for existence.

The feeling that the government should assist in the furtherance of agricultural research was manifested more than a

hundred years ago, though the movement, like other great revolutions, progressed slowly. In 1785 Washington urged the importance of establishing a national university in which agriculture should be taught, thus placing himself squarely on record as favoring the promotion of agricultural science by the general government. In 1792 Columbia University, then King's College, made provision for the teaching of agriculture; New York established an agricultural college in 1853, followed by Maryland a year later. Germany established the first governmental experiment station in 1851. While the United States was not the first nation to endow agricultural research work, the establishment of the Department of Agriculture in 1862 was almost coincident with the establishment of the agricultural colleges; and the fuller recognition of the Department by giving its head the title of "Secretary" and making him a cabinet officer was very nearly coincident with the establishment of the experiment stations.

Since their establishment the governmental appropriations for the Department, for the agricultural colleges, and for the experiment stations have each been gradually and regularly increased, and in very many cases the funds for the colleges and stations have been still further increased by appropriations made by the several States. At the present time the State and local appropriations are making the most rapid increase, showing a strong public sentiment in favor of using government funds fo the promotion of our basic industry.

These appropriations, national, State, and local, amount to many millions of dollars annually, all given for the furtherance of science as applied to agriculture. The colleges and stations are now receiving about $4,000,000 annually, and of that amount about three-fourths is given by the national government. In addition to appropriating that amount, the national government also employs the largest force of agricultural investigators in the world. The colleges and stations have approximately 7,000 men in their employ, though only a portion of the college men are working for agricultural advancement. There are now about a thousand high schools in which agriculture is made a leading feature of the work, and in many of the States the study of agriculture is made compulsory in all the public schools.

Research must precede the giving of instruction. In most other lines of work we begin at the foundation and build upward, but in educational matters, in the dissemination of knowledge, the process must be reversed; the source must be higher than the outflow; the teacher must know more than the taught. But the true teacher, no matter how far in advance of his students he may be, soon finds the limit of what he himself has been taught, and then original research must come before further instruction is possible. Research in any branch of science is an exceedingly expensive work, requiring both time and money for which there can be little expectation of direct return to the worker, however much the results may benefit the public. Few investigators have such private means that they can meet the necessary expenses for any prolonged investigation, nor are they financially able to give up the time needed for its accomplishment with no hope for financial rewards. I am sure you will agree with me that there are few college or station men who could afford to undertake such work without assistance from outside sources, nor would it be right to ask them to do so. Their work is for the benefit of the public, and it is only just that the public should provide for their needs while they are doing its work. In fact, the work of original research and investigation has been confined, almost wholly, to those who have been in some manner supported by funds coming from public sources. While it is true that the greatest institutions for agricultural research, that founded by Laws and Gilbert, and the one recently founded by Dr. Kolaceoskij in southern Russia, are supported by private endowments, the fact remains that by far the greater part of the work done for the promotion of scientific agriculture is made possible only through the use of public funds.

In this work the national government may act in either one, or both, of two ways: it may take up the work directly through its own corps of workers, or it may provide funds for local institutions, the experiment stations, agricultural colleges and universities, to investigate problems in which they may be specially interested. The discussion as to which is the better method began many years ago, before the establishment of the experiment stations, or even of the agricul-

tural colleges. Washington advocated a national institution, while several of the States established local colleges.

The more earnest discussion of the matter began with the question of establishing agricultural colleges, about 1860. All thinking men were agreed that in a country like this, where agriculture rather than mining or manufacturing is the basis of prosperity, there should be afforded an ample opportunity for both research and for giving of instruction, but whether these objects could be accomplished best by some central institution for the study of mostly abstract problems, or by many institutions located in as many different regions for the study of local conditions and methods for more immediate practical application, was a mooted question. In the early seventies when the experiment stations were only a hope, there was another earnest discussion of the matter, many of our best men thinking that all the real experimentation and investigation could be conducted best by the Department of Agriculture, while the work of teaching and of demonstration should be given over to the several State institutions. I think that now no one questions the wisdom of the final decision that each State should have its own institution for the study of local problems and for giving instruction in local methods. For this work the original endowments of the several institutions were provided by the general government, though the detail of the work to be done in each was left to the judgment of the individual States.

The Department of Agriculture as a distinct part of the general government, the colleges for the giving of instruction in scientific work, and the experiment stations for the study of unrecognized laws and the devising of better farm methods, were all needed, and each soon found that it had more problems to solve than could be undertaken with the funds available. Congress gradually increased the funds given to the Department of Agriculture and to the experiment stations, and nearly every State made liberal appropriations for the agricultural colleges, while many of them gave additional funds to the experiment stations. Congress did much to relieve the stringency of station funds by the adoption of the Adams bill, which provided funds for work which should be strictly investigational in character.

In too many cases the station funds had been diverted to the general work of the college with which it was connected; to police work in the inspection of fertilizers, feeding stuffs, insecticides, and other lines having no connection with agricultural experimentation. In some cases experiment station funds were used in propaganda work—in the sending of lecturers to distant parts of the country, often accompanied by a carload of exhibits to exploit the natural resources of the lecturer's "native" State. While such work may have been of inestimable value to the State, it was in no sense experiment work, and such a use of station funds was never contemplated by those who labored so faithfully to establish stations whose object should be "to conduct original researches."

Fortunately for the science of agriculture the provisions of the Adams bill were more closely guarded, and that fund cannot be used for promoting the sale of the "abandoned farms" of New England, the "reclaimed lands" of the Gulf region, or the "Fresh Water River Project" of the arid southwest. The present law permits the agricultural colleges to teach the Chinese language or the properties of the fourth dimension; and the experiment stations may use their funds in the printing of bulletins which are nothing but compilations from standard text-books, or for the advertising of lands which may be for sale within the State; but, up to this time, the Adams fund has been held sacred to its original purpose—to investigations for the promotion of the real science of agriculture.

Of course it is perfectly proper and legitimate for a State to appropriate funds for the advertising of its resources in any manner which it may choose. Unfortunately for the stations, however, in nearly every case where such appropriations have been made the work connected with the scheme has been put on the shoulders of the experiment station men, whose salaries are paid from funds appropriated by Congress for experiment work only. This is an injustice, both to the government which provides the funds and to the men who are held responsible for the success of the station. In making this criticism I do not refer to the "diary trains," the "hog trains" and other strictly educational trains which remain within the State where they originate, and which are often of very great value

in "publishing" the results of experiment work. Funds used in the preparation and management of such trains often accomplish far more for the promotion of scientific agriculture than could be done by the printing of bulletins. The matter against which I protest is the using of experiment station funds simply to attract immigrants from distant States.

Though the larger parts of both the college and the station funds have, up to this time, come from the national government, the relations of the national appropriations to those made by the several States, and the work which can best be undertaken by each, is a matter which has not yet, and perhaps never will, be fully settled. Whether the nation should, through the Department of Agriculture, control the funds which it expends for the promotion of scientific agriculture, and whether the end which we all desire can be secured most effectively by the direct work of the Department, or by the appropriation of funds to the immediate control of the several State authorities, is a matter which may well receive our most careful attention. This has been the subject of many discussions, though few have attempted to draw any definite line of separation between the work which can be done most systematically and effectively by the national government, and that which can be done better and more thoroughly by State institutions. The usual decision, from an academic standpoint, has been that investigations in pure science could usually be conducted most economically by the national government, while investigations and experiments in applied science could be conducted most effectively by local institutions.

State boundaries bear no relation to scientific facts. The uses of protein are the same in Maine that they are in California, and the office of protein in the economy of the living animal may be investigated in the one place as accurately and reliably as in the other. Digestible protein, simply as digestible protein, performs the same office everywhere, and its action and qualities need be investigated only once. The solution of the problem is of universal application, and such work may well be done by the national government. On the other hand, the most economical source of the protein needed for local consumption varies with every section of the country, and with almost every farm. That is wholly a matter for

local study, and each State can solve that problem for itself far more satisfactorily and economically than it can be done by the national government.

An examination of the soils of the country is of the highest importance. In this work the national government is making a detailed survey of many typical regions, and this survey will doubtless soon cover our entire area. Such a survey, when completed, will be of inestimable value in many ways; but to have its greatest value it must be made on some uniform system, using the same methods of work and the same descriptive terms everywhere. In such work uniformity in methods is of more importance than the choice of details, and can be secured only by national supervision. But such a survey as is being made by the national government cannot tell everything. It may find that certain soils are duplicated chemically and physically, in Minnesota and Mississippi, but it does not follow that both areas can be used with equal profit for the growing of cotton or of flax. The crops which can be grown to the best advantage on these duplicate soils can be determined far better by the State than by the national government.

There are certain lines of agricultural work which seem, logically, to belong to the national government. Within the memory of many of you who are here to-night we had only about three hundred different kinds of plants in cultivation. The French, the Hungarians, the Russians, the Japanese, the Peruvians, and all other peoples had valuable plants of which we knew nothing, and we had no way to learn of them or to secure them for trial. No single State government could afford to send an explorer around the world to look for things which might, or might not, be of value when planted within its own narrow boundaries. At one of the early meetings of this Association it was proposed that we ask each experiment station to contribute one hundred dollars to send some one to the Far East to find what he might which would be of value in the Far West. It was found impossible to carry such a plan into execution, but the proposition soon bore fruit in the appointment of an agricultural explorer by the national government.

Since that time nearly every corner of the world has been

visited by some of our scientists, and more than thirty thousand different kinds of plants have been introduced for the possible benefit of the American farmer. Of course many of these introductions have soon proved themselves unsuited to our conditions, and have been discarded. Others which were brought in for certain sections of the country soon showed themselves better adapted to some very different section; as, an alfalfa which it was thought would have special value for the arid regions of Texas proved of little value there, but one of the best varieties for the equally arid, but colder, region of the Dakotas. The work of introducing new crops seems to belong, logically, to the national government, while the study of their adaptation to specific uses and their place in the farm economy seem to belong to the local institutions.

The study of farm management, in its broadest sense, is national rather than State in its character. The cost of equipment for a hay farm, a dairy farm, or for an establishment for mixed farming is practically the same in Colorado and in Alabama. The farmers of every State are vitally interested in that problem, and one investigation and one solution will cover the needs of the entire country. The same is true of a study of the best plan for mixed farming, as the proportions of pasture, meadow, and sales crop vary little, no matter whether the sales crop be wheat, potatoes, corn or cotton, or whether the farm be in New York or in Louisiana.

There are many agricultural problems which are quite local, and which can be studied most advantageously by the State institutions. The proper treatment of cranberry bogs is of great interest in some parts of New Jersey, Massachusetts, Michigan, and Wisconsin, but other States have little interest in the matter. New York, Ohio, and California produce immense quantities of wine, but more than half the country is now in the prohibition column, and so is not interested in the best temperature and methods for fermenting must; Louisiana is vitally interested in the production of cane sugar, a matter in which other States have little interest; Florida is growing avacados, pineapples, guavas, mangoes and other fruits which we of more northern regions know only as we see them in the markets; Texas has almost a monopoly on the

growing of Bermuda onions, New York on the production of peppermint, South Carolina on the production of the best grades of sea island cotton, and other States on other special crops.

In the study of such specialties, in the investigation of all local industries and in the development of the best and most economical local methods, the local institutions, the agricultural colleges and experiment stations, can do the work better and more economically than it can be done by the national government. This is especially true for a good part of our educational work in agriculture, which must deal so very largely with local conditions and methods. It would be impossible for a single national agricultural college to do the good work which is now being done by the State colleges, though a national institution which should do work similar to that now done by the Graduate School of Agriculture in its biennial sessions would be of inestimable value to both teachers and investigators. Is it too much to hope that such an institution may some time be provided?

I am sure that we all agree in wanting to secure the greatest possible amount of work, and to secure it as the least possible cost consistent with accuracy. Just how we can do this—just where we are to draw the line between the use of State and national funds—it is sometimes hard to decide.

No State experiment station has ever had all the funds it needed for its immediate, pressing problems. The national government has shown its desire to assist by the liberal appropriations which it makes. If a State station can secure still further assistance by means of the detail of workers or by the use of additional funds it would seem the part of the real scientist to accept such aid in the same spirit in which it is offered. The real investigator, the man who is looking for facts, for principles, and for the true laws of agricultural science, should care more for the end than for the means.

Under our present loose arrangement there is often an unnecessary duplication of work by the national government and some of the stations, as well as among the stations themselves. This is unfortunate, as it entails loss of time and money which could be better used for other purposes. Just how great this loss may be we have no means of knowing, but

greater care should be exercised on the part of each to avoid such duplication. The ideal plan for this would be to have all the national and State work planned by representatives from each of the institutions interested, a sort of "program committee" which should fill the gaps, cut out unnecessary duplications, and so make our work better rounded and more complete, as well as more economical; but that plan is not now practicable, though we hope it may be put into operation as one of the forerunners of the millennium. There is some waste in all work, and perhaps it is not greater here than elsewhere.

As I said in the beginning, all original investigation must be the work of an individual. And more than that—each line of investigation to be taken up must be decided by the personal interests and predilections of the investigator. We must not ask Dr. A, whose interests are wholly in the line of soil management, to make special investigations in insect diseases; nor should we ask Dr. B, that eminent student of animal nutrition, to give his time to a study of the duty of irrigation waters, even though he may be one of the station workers in Utah or Arizona. Each man, each individual worker, must be allowed the broadest latitude in his choice for a field of investigation. In no other way can we secure his best work. If he is a station man and is working on a problem of world-wide interest he should not be disturbed in his work but should be given every assistance possible, not only by his own station where he may have originated the work and carried it forward to a promise of definite results, but, if necessary, he should be given still further aid by the national government. If he is working on a problem of local interest only, his own State may well give him the needed facilities.

Agricultural investigation is of recent origin; the establishment of institutions for the study of agricultural problems is recent; all work for the promotion of real agricultural science is very recent. When the work becomes older, when we have the experience of a few generations to guide us, and when we learn how we can do our work most economically and most effectively, I believe that we shall ask the general government to solve our problems of general interest, while problems of local interest will be left to the local institutions.

The Improvement of Timothy.

By W. J. Beal,
Amherst, Mass.

What little I have done pertains to timothy (*Phleum pretense L.*) as adapted to the needs of farmers of Michigan.

1. Timothy is popular with the farmers because the seed for an acre costs but little.

2. Because the merchant and the farmer are apt to know the seed when they see it.

3. The seeds start promptly, making strong plants.

4. The plants differ so widely from most others that the farmer usually recognizes the grass when he sees the spikes in flower and later.

5. P ants are hardy.

6. It cuts one good crop in July when the weather is often favorable for haying.

7. The quality is good,

8. Dealers and purchasers recognize timothy.

9. After flowering it deteriorates less rapidly than orchard grass, hence suffers less if cut late.

Timothy has some marked defects:

1. It flowers late and is fit for making hay late in the season; hence many meadow weeds mature and scatter seeds before haying time.

2. The aftermath is too late to be of much account for pasture or mowing.

3. It is not first rate for pasture, especially by sheep and horses, as they eat off the bulbs or corms and kill it out.

4. Timothy usually is not reliable for more than three years.

It has long been well established that a mixture of two or more grasses, clovers or other forage plants will yield considerable more than either one grown by itself. Michigan farmers for some reason usually sow a mixture of timothy and red clover. The clover is ready to cut two to three weeks before time for cutting timothy. In my estimation the most

desirable quality in the improvement of timothy is to secure plants that are vigorous and in blossom when red clover is ready to mow.

Dr. A. D. Hopkins* in West Virginia secured an early flowering race in 1894 (No. 38), but it lacks vigor. While at Michigan Agricultural College, I began to experiment on a small scale on rich soil and continued for six years to try to get prolific plants from seedlings of Hopkins' extra early. The second year one hundred seedlings of the extra early flowered early, but they were not strong plants. From seedlings to flowering they looked as though they had been cast in the same mold, indicating that they were already thoroughbred, reminding me of what Dr. Hopkins said of seedlings, all of the plants in each row exhibiting peculiar and uniform characters.

Two years more gave me flowering seedlings of one of these grown from No. 38 showing some variation among the plants, some of which were later in maturing. Continuing the third time in the same line, in the sixth summer there was still some variation—a portion of the plants were as early as No. 38 and more vigorous, but not as vigorous as I hoped to secure. At the end of the seventh year I resigned my position at the college, occupied for forty years, leaving my plants in charge of another, where they have been destroyed, as no new man ever cares to continue an experiment begun by some one else.

These few experiments were made in the botanic garden, and were not made at the expense of the Hatch fund or the Adams fund.

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*See his reports in Proceedings of this Society for 1895, 1898, and 1899.

Special Apparatus for Cranberry Investigations.

By Wm. P. Brooks,
Massachusetts Experiment Station.

The cranberry industry in Massachusetts is recognized as one of the important special industries of the State. The annual crop varies quite widely, both in size and market value. The total yield sometimes reaches about 375,000 barrels, while the total market value is frequently as great as $2,000,000. The number of acres is approximately 8,500, and the total acreage is increasing quite rapidly.

At the present time Massachusetts produces more cranberries than all the other States of the Union put together. The production of cranberries in artificial bogs began about sixty years ago. The industry is confined almost exclusively to Plymouth and Barnstable counties. In this portion of the State are found in abundance the peculiar swamp soils which suit the cranberry, and in the immediate vicinity of the swamps are boundless deposits of sand which is as essential to the making of a satisfactory bog as the peat or muck soil which lies at its foundation.

Since among my hearers are doubtless included individuals who have never seen a cranberry bog, a brief statement of the method of making and a description of the conditions existing will be of interest and necessary for an understanding of the reasons why special apparatus for investigation of its fertilizer needs seemed necessary.

The foundation of the cranberry bog is a cumulose soil of swamp origin. It may be either wooded or grassed when the construction of the bog is undertaken, though doubtless all were originally wooded. The best bogs are those which succeed white cedar (*Chamæcyparis thyoides*).

The first steps in the preparation of a bog are: The removal of any stumps and roots which may be present; reducing to a grade, which within dykes should be nearly level; the inversion of any turf which may be present; the putting in of

ditches for the drainage of the bog, as well as for use in connection with sub-irrigation and flooding; construction of dykes by means of which the water can be held under control, and any given section of the bog flooded at will; and finally covering with sand, which should be sharp, clean, free from dust, and moderately coarse, to the depth of about four inches.

When these successive steps have been completed the bog is ready for planting. This is always done in the spring, and planting consists in pushing unrooted cuttings four or five in a bunch, down through the sand to the layer of muck or peat below. The cuttings are usually set at a distance of about one foot each way. They are laid flat on the sand and with a blunt crotched stick the middle of the bunch is pushed directly down through the sand. Since the soil below is always kept moist such cuttings almost invariably root and the vines soon begin to grow and spread. A few berries are occasionally produced the second year, though not usually in sufficient numbers to repay picking. The third year there may be a moderate crop, while the fourth year the bog, if it has done well, should produce a full crop of fruit.

When the production of cranberries on artificial bogs first began to be practised it was not customary to use fertilizer, but for a number of years many growers have been in the habit of using moderate amounts of fertilizers, and while there is considerable difference of opinion, the conviction is quite general that some fertilizer is needed and that its use will be followed by increased profits. Very little, however, is as yet known as to the special fertilizer requirements of the crop; and there accordingly appears to be great need of investigation.

Investigation by means of plots in the open bog, while it will doubtless have its uses, is attended by certain difficulties not met with in the case of upland crops. All the best cranberry bogs must occasionally be flooded. Water is used during the growing season (or may be so used), as a means of protection from frosts and as a means of destroying injurious insects or protecting the crop from their ravages. All the best bogs, moreover, are flooded late in the fall and the water is held throughout the entire winter; indeed it is not usually drawn off until middle or late spring. The free use of water which has been referred to must result in the open bog in

transferring fertilizer elements applied to plots from one to another. Moreover, the high level at which the water is commonly held in the bog during the growing season (usually within ten to sixteen inches of the surface of the bog) produces soil conditions entirely different from those existing in uplands.

Without doubt there are many bogs which as yet require no fertilizer, but the artificial cranberry bog well cared for is long-lived and must, it is believed, ultimately require enrichment.

The special apparatus which I am to describe has been designed to create, under full control, conditions as nearly as possible identical with those which exist in a cranberry bog; and second, while reproducing these conditions as perfectly as possible, the aim has been to design a plan which will permit a close chemical study of both the soil and the water in the bog, and at the same time make it possible to follow the chemical changes in the fertilizer materials applied, and in the soil and soil water as affected by these materials.

Figure 1 shows a plan of a portion of the equipment which has been put in. I may designate as a unit the two cylinders A and B. Each of these cylinders is four feet in depth and is made up of a specially manufactured Akron tile, set bell end up. The larger cylinder in which the plants are growing is two feet in diameter, the smaller six inches. These cylinders were so set as to be water-tight in a concrete trough four feet in depth, and tested; and after being set and all connections made the earth was filled in about the cylinders in order to produce normal soil conditions as nearly as would seem to be possible.

The manner of setting the cylinders and connecting them is shown in the sectional drawing (Fig. 2). It will be noticed that the lower end is bedded in the concrete and that the two cylinders are connected by a pipe. This is of brass and connects at either end with a funnel which is covered with a brass strainer. Over the strainer leading to the pipe in the bottom of the large cylinder was inverted an earthenware pan eight inches in diameter. The space around the pan and for about two inches above it was filled in with water-washed pebbles.

It will be readily understood that the idea in view was to produce, in the bottom of the larger cylinder, conditions which would allow the somewhat free circulation of water while at the same time preventing the peat from clogging the strainer.

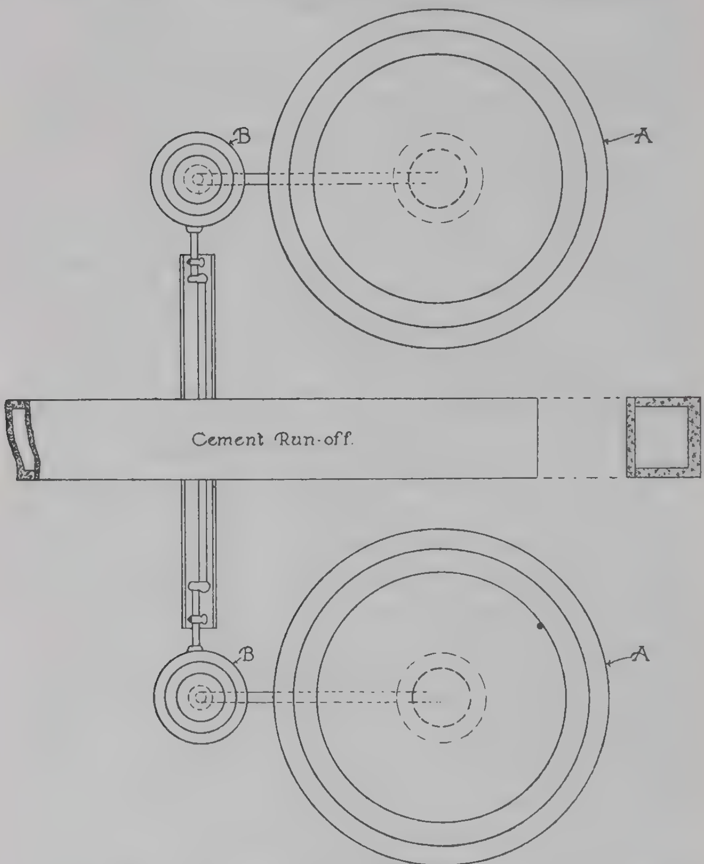


Fig. 1.—Plan of equipment for cranberry experiments. *A*, large cylinder in which plants are grown. *B*, small cylinder for controlling height of water table.

It will be understood that while, of course, the pipe and strainer and the soil which fills the larger cylinder will to some extent retard the passage of water, this must tend to stand at the same level in the two cylinders. At D one foot below

the top of the smaller cylinder was drilled a half-inch opening and in this was carefully set a jointed brass pipe. By raising or lowering the tip of this pipe the water level in the smaller cylinder may be held at any point between the opening in which it is set and the surface of the bog, while when flooding is necessary, we have only to close the cock in the pipe.

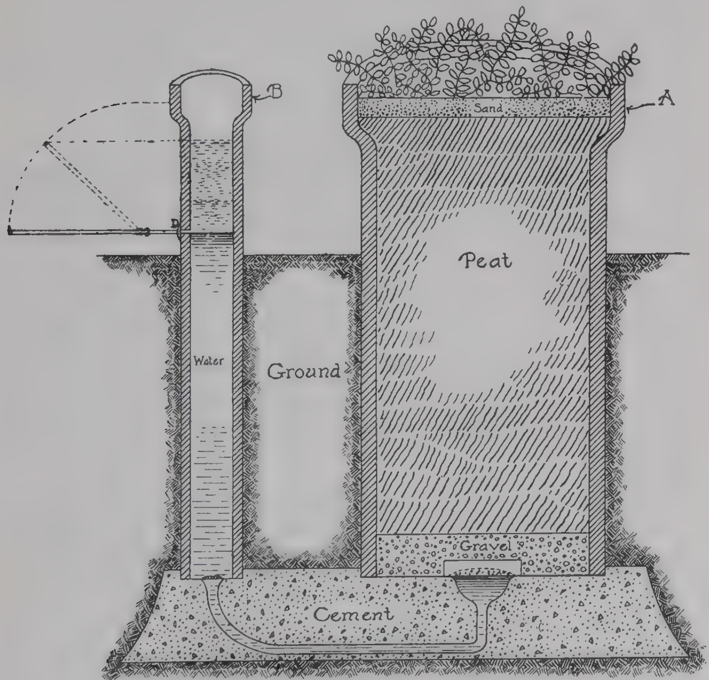


FIG. 2.—Vertical view of cylinders for cranberry experiments, showing method of setting and connection.

In each of the larger cylinders was placed an equal weight of very thoroughly mixed white-cedar swamp peat, which was consolidated as thoroughly as possible as it went in. Above the peat was placed four inches of sand, which also was put in by weight.

Our vine cuttings were set in June, 1910. Every one lived and the vines have made a splendid growth. At the present time they entirely cover the surface and should give a crop of fruit next year.

I have stated that it is customary to flood the cranberry bog to a considerable depth for the purpose of affording winter protection. The water applied must be sufficiently deep that ice does not form on the vines themselves, as should it do so these might be pulled or otherwise injured. It was thought best to provide means whereby the vines in this experimental outfit could be flooded. It was not thought desirable to make the permanent cylinder sufficiently high to make flooding possible on account of the injurious effect of the shade during the growing season.

Accordingly, galvanized iron cylinders one foot in height are cemented into the bell ends of both the large and small cylinders, late in fall (when it is desirable to flood), with a mixture of asphaltum and tallow. These cylinders are readily removed when the water is drawn off in the spring. It will not be necessary to flood in these experiments during the growing season, for we can readily protect from frosts if this seems to be necessary by covering; while we do not anticipate trouble with cranberry insects since our outfit, which is in Amherst, is located at so great a distance from centers of cranberry production.

The arrangement of these experimental units is in two rows of fifteen each, and to carry off the water which may be discharged from the pipes a concrete trough lying midway between the two rows has been constructed. (See Fig. 1.) This is covered with plank.

The climate of Amherst is so severe that without protection ice would undoubtedly form the full depth of the winter flowage. To guard against this, which, as has been explained, would be injurious, the entire area occupied is covered late every fall with a shed roof and this in turn heavily covered with mulch to prevent excessive freezing.

It is believed that by means of this special apparatus we have practically put nature as she works in a cranberry bog into harness. By raising or lowering the discharge tip of the pipe set into the smaller cylinder, and the addition of water when a higher level in the bog is desirable, we shall be able to control the water conditions in our little bogs. This is accomplished in actual practice by raising or lowering the water in the ditches.

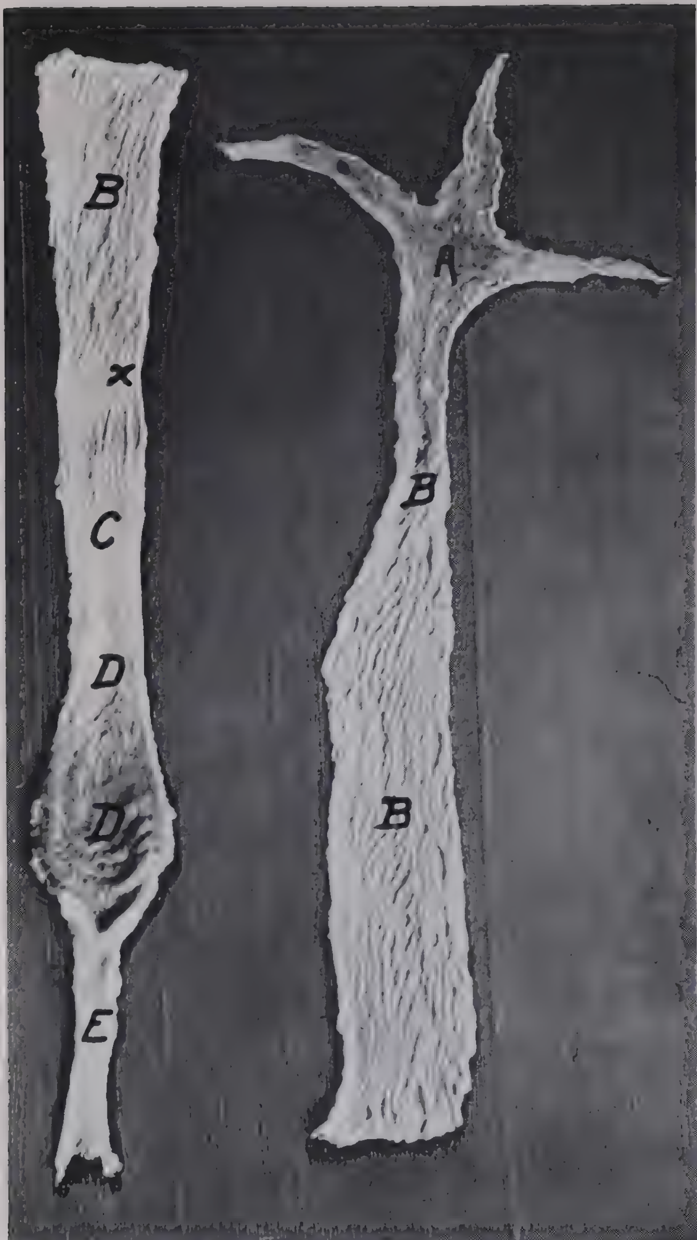


FIG. 3.—Photograph of a hen's oviduct which has been removed, slit longitudinally throughout its length and opened out flat.

The Secretory Activity of the Oviduct of the Domestic Fowl.*

By Raymond Pearl,
Maine Experiment Station.

The oviduct of a laying hen is divided into five main parts, readily distinguishable by gross observation. Beginning at the anterior end of the organ these parts, in order, are: (*a*) the infundibulum, or funnel, (*b*) the albumen-secreting portion, (*c*) the isthmus, (*d*) the uterus or "shell gland" and (*e*) the vagina. (See Fig. 3.)

Each of these parts is generally supposed to play a particular and exclusive rôle in the formation of the protective and nutritive envelopes which surround the yolk in the complete egg as laid. Thus, the funnel grasps the ovule at the time of ovulation; the glands of the albumen region secrete the different sorts of albumen (thick and thin) found in the egg; the shell membranes are secreted in the isthmus; and finally the glands of the uterine wall secrete the calcareous shell. This is, in brief, the classical picture of the physiology of the oviduct.

For some years past experiments and observations have been systematically carried on in the biological laboratory of the Maine Station, with the object of acquiring a more extended and precise knowledge of the physiology of the hen's oviduct than is to be gained from the literature. It is the purpose of this paper to present a certain part of the results which have been obtained regarding the physiology of two of the lower divisions of the duct, namely, the isthmus and the uterus. Our results indicate that these portions of the oviduct perform certain functions which have not hitherto been observed or described.

*This is an abstract of a more extended paper having the title "Studies on the Physiology of Reproduction in the Domestic Fowl.—V. Data regarding the Physiology of the Oviduct." The complete paper has been published in the Journal of Experimental Zoology, vol. 12, 1912, pp. 99–132.

So far as the existing literature indicates, the opinion has been held by all who have worked upon the subject that the particular functional activity of each portion of the oviduct (as above described) is *limited* to that portion. Thus it is commonly held that when an egg in its passage down the oviduct leaves the albumen portion it has all the a bumen it will ever have; when it leaves the isthmus it has all its shell membrane, and when it leaves the uterus all its shell. On this prevailing view there are in the albumen portion only albumen-secreting glands, in the isthmus only membrane-secreting glands, and in the uterus only shell-secreting glands.

The entire truthfulness of this assumption was first rendered doubtful by the observation, frequently made in connection with routine autopsy work, that eggs in the isthmus with completely formed shell membranes, and eggs in the uterus bearing in addition to the complete shell membranes a partially formed shell, weighed considerably less than the normal average for laid Barred Plymouth Rock eggs. This observation led to an inquiry as to whether (*a*) this apparent lower weight of presumably completed, but not laid eggs, as compared with those which had been laid, was a real phenomenon of general occurrence, and (*b*) if so, to what it was due. Does the egg increase in weight after the formation of shell membranes and shell merely by the absorption of water, or by the actual addition of new albumen? These are the problems with which the present paper has to do.

OBSERVATIONS AND EXPERIMENTS.

In the normal egg of the hen there are certainly three and possibly four different albumen layers which can easily be distinguished on the basis of physical consistency. These are: (*a*) the chalaziferous layer. This is a thin layer of very dense albuminous material which lies immediately outside the true yolk membrane. It is continuous at the poles of the yolk with the chalazæ, and is undoubtedly formed in connection with those structures. It is so thin a layer that it might well be, and often has been, taken for the yolk membrane. (*b*) The inner layer of *fluid* (thin) *albumen*. This layer is only a few millimeters in thickness and there is some doubt as

to its existence as a separate distinct layer. (*c*) The *dense albumen.* This is the layer which makes up the bulk of the "white" of the egg. It is composed of a mass of dense, closely interlaced albumen fibres, with some thin albumen between the meshes of the fibrous network. The dense albumen as a whole will not flow readily, but holds itself together in a flattened mass if poured out upon a plate. (*d*) The outer layer of *fluid albumen.* This is the principle layer of thin albumen, which makes up the fluid part of the "white" observed when an egg is broken.

In order to determine when and where these different layers were added to the egg, particularly the last one, (*d*), hens having an egg in the oviduct were killed and the location and condition of the egg determined. Many such autopsy records agree in showing that *the egg does not receive the outer layer of thin fluid* (layer *d*) *during its sojourn in the so-called albumen secreting portion of the oviduct.*

A single illustration protocol may be cited here:

Autopsy No. 301. Hen No. E 39. July 14, 1909.—When this bird was killed an egg was found at the lower end of the albumen portion of the oviduct just about to enter the isthmus. Not yet having entered the isthmus the egg had no shell membrane upon it. It consisted merely of a yolk surrounded by albumen. The outermost layer of this albumen was dense and corresponded to layer *c* described above. There was no trace of thin albumen (layer *d*) on this egg, although it was just on the point of leaving the so-called albumen region of the oviduct.

The successive autopsy records reported in the complete paper show that, beginning with an egg 11 cm. away in front of the isthmus and going downward in the duct until the actual boundary of the isthmus is reached, there is no quantitative change in the albumen secretion. Whatever albumen is added to the egg immediately prior to the formation of the shell membrane is of the dense fibrous variety (layer *c*), so far as direct observation indicates.

In cases where one-half of the egg lies within the isthmus and bears a membrane, while the other half is in the albumen portion and has no membrane, it can plainly be seen that *the shell membrane is deposited directly on the outer surface of the*

thick albumen (layer *c*), *and that no trace of the thin albumen* (layer *d*) *is present at the time the membrane is formed.*

A detailed and careful study of the weights of the several parts of the egg (yolk, albumen, shell membranes) in eggs taken from different levels of the oviduct, leads to the following results:

When the egg leaves the albumen portion of the oviduct it weighs roughly only about half as much as it does when it is laid. Nearly all of this difference is in the albumen. Thus these weighings fully confirm the conclusion reached from direct examination of the eggs, as already described. The evidence thus shows that the egg gets all of its thin albumen (layer *d*), which constitutes nearly 60 per cent by weight of the total albumen, only after it has left the supposedly only albumen-secreting portion of the oviduct, and has acquired a shell albumen, and the shell is in process of formation.

The weighings show that in general the farther down the oviduct the egg proceeds the more albumen it gets. Very nearly one-half the total weight of albumen of the completed egg is added in the uterus, an organ hitherto supposed to be entirely devoted to shell formation. Clearly very much more albumen is added to the egg in the uterus than in the isthmus. This, of course, does not necessarily mean any more rapid rate of secretion in the uterus, because of the time element involved. The egg stays much longer in the uterus than in the isthmus.

The rate of albumen secretion per unit of time as the egg passes down the oviduct was determined, and was found to be expressed by a parabola,

$$y = 17.5915x - .8171x^2 - 0.4164$$

in which y denotes percentage of albumen and x time in hours during which the egg has been in the oviduct.

There is scarcely any change in the rate of secretion until nearly the total amount has been acquired by the egg. There is not the slightest evidence of any break in the rate of secretion of albumen after the egg leaves the so-called "albumen portion" of the duct. From the time the yolk enters the upper end of the "albumen portion" there is a gradual dim-

inution of the rate of secretion of albumen, giving rise to the parabolic curve. But there is no sudden change. The egg not only gets more than half of its total albumen after it leaves the "albumen portion" of the duct, but it takes this at nearly the same rate as it did the earlier part.

While the two lines of evidence already presented amply demonstrate that the "thin" albumen is added to the egg after it leaves the so-called albumen portion of the duct, it seemed advisable, because of the novelty of the results, to collect still further evidence of another kind. This evidence has to do with the nitrogen content of the albumen in eggs taken from different levels of the oviduct.

The point of greatest interest and importance in connection with these chemical data hinges upon the *absolute* amount of nitrogen in the albumen. Since its is solely the "thin" albumen layer which is added after the egg leaves the so-called albumen portion of the oviduct, the possibility is at once suggested that what happens in the lower portions of the duct is not a true secretion of another albumen layer, but merely a taking up of water from the blood by osmosis, and a dilution or partial solution of the "thick" albumen already present. Such a view assumes, in other words, that all that is added to the albumen after the egg enters the isthmus is water.

Clearly the only way to test finally the validity of this idea is to make chemical determinations. What the figures from the analyses show is that the oviduct egg *has absolutely less nitrogen in its albumen than the normal laid egg of the same hen.* This, of course, is what would be expected if there is an actual secretion of albumen by the glands of the isthmus and uterus, and this secretion is added to the egg. It means that these oviduct eggs have been removed before they received their full amount of albumen.

If it were the case, on the contrary, that only water was added to the egg after it left the albumen portion of the duct, it would be expected that the *amount of nitrogen* would be the same in an oviduct egg from the isthmus or uterus as in the normal laid egg. *The chemical data clearly indicate that there is a definite addition of albumen to the egg in the isthmus and shell gland, and that the "thin" layer does not represent solely a dilution of the "thick" layer.*

SUMMARY OF RESULTS.

Putting all the evidence together, the following account of the processes by which the hen's egg acquires its protective and nutritive coverings summarizes the results of the present study.

1. After entering the infundibulum the yolk remains in the so-called albumen portion of the oviduct about three hours, and in this time acquires only about 40 to 50 per cent by weight of its total albumen and not all of it as has hitherto been supposed.

2. During its sojourn in the albumen portion of the duct the egg acquires its chalazæ and chalaziferous layer, and the "thick" albumen layer.

3. Upon entering the isthmus, in passing through which portion of the duct something under an hour's time is occupied, instead of three hours as been previously maintained, the egg receives its shell membrane by a process of discrete deposition.

4. At the same time, and during the sojourn of the egg in the uterus, it receives its outer layer fluid, or "thin" albumen, which is by weight 50 to 60 per cent of the total albumen.

5. This "thin" albumen is taken in as a dilute fluid by osmosis through the shell membranes already formed. The fluid albumen added in this way diffuses into the dense albumen already present, dissolves some of the latter and so brings about its dilution in some degree. At the same time the fluid albumen is made more dense in this process of diffusion, and comes to have the consistency of the thin albumen layer of the normal laid egg. The fluid albumen taken into the egg by osmosis is a definite secretion of glands of the isthmus and uterus.

6. The addition of albumen to the egg is completed only after it has been in the uterus from five to seven hours.

7. Before the acquisition of albumen by the egg is completed a fairly considerable amount of shell substance has been deposited on the shell membrane.

8. For the completion of the shell and the laying of the egg from twelve to sixteen, or exceptionally even more, hours are required.

Some Sugar Beet Problems.

By W. P. Headden,
Colorado Experiment Station.

Some of the problems which present themselves in connection with the beet sugar industry in Colorado are such as would be considered as naturally arising from our practice of irrigation; others of them are not. The seeping and alkalization of some areas, unless early and adequate drainage be provided, was an evident danger from the beginning, and these have affected districts of considerable size. Other difficulties, however, have developed and the problems have grown in complexity and seriousness.

I do not think that any one acquainted with the facts will question the correctness of the statement that there has been, during the past seven years, less sugar in the beet crop of the Arkansas Valley than in the years previous to 1905 and running back to the earliest experiments made to ascertain the feasibility of making this crop the basis of an industry. I think that I am justified in asserting that there has been a falling off of at least 2 per cent from the average of the late nineties of the last and the first three years of the present century. It has further been observed that the beets do not keep well and that they often produce an abnormal amount of molasses.

The production of $5\frac{1}{2}$ per cent of second green syrup, calculated on the weight of the beets, is probably a fair one, but the beets under discussion produce from 2 to 4 per cent more than this.

The questions raised by these facts are important ones, and the causes assigned by the public as accounting for all of these untoward facts are various. "Climatic conditions" will account for some variability in the crop from year to year, and in the case of a single crop of poor quality it may suffice to attribute it to climatic conditions largely because it is a convenient way of explaining an evident fact which we do not

know how to explain in any positively definite way; but when we find a series of years during which the poorer quality of the beets remains a fact, "climatic conditions" fails to satisfy us as a sufficient cause. Besides, the variability in the quality of the individual crops grown in the same small district subjected to the same climatic conditions leaves too many instances to be explained by special causes.

The favorite explanation with many is alkali and seepage. Experiments with beets grown on undrained alkali land for four consecutive years did not show any justification for the assumption generally made that these conditions bring about a poor quality in the beets. At the time these experiments were made our examination of the beet was confined to determining the sugar content, apparent purity, the percentage of ash and its composition, and the making of the ordinary fodder analysis in which we obtained the total nitrogen.

Several varieties of beets were grown each year and samples were taken from beets of the same variety when possible, grown on good farm land for the purpose of comparison. The land on which these experiments were conducted, especially in certain parts of it, became heavily encrusted with alkali in both winter and summer, under favorable weather conditions. These incrustations sometimes exceeded one-half inch in thickness. The results of these experiments showed no prejudicial effect of the alkalis upon the sugar content of the beet; in fact, some of the best beets came from those portions of this plot of ground which were very rich in alkali. Observations on other lands have led us to the same conclusion, *i. e.*, that the ordinary alkali occurring in our soils is not of itself injurious to the quality of the beet.

The height of the water-table in this piece of land was observed by means of a series of wells and, excluding extreme variations, for instance a short period during which the water rose above the surface during the growing period, we found it to range from 2.3 to 4.0 feet.

In regard to the effects of water in the soil, the undrained alkali land experimented on, with the water-table varying from 2.3 to 4.0, is assumed to have been as wet as any land on which persons would be likely to grow this crop, and the beets were both good in quality, so far as the investigations

then made indicated, and more than average in quantity. A number of similar cases have been observed, one in particular, which was examined in the month of October when the spaces between the rows of beets were found to be heavily incrusted with alkali and the water-table was on that date within 18 inches of the surface. I obtained the record of this piece of land from the factory to which these beets were delivered, not only for this but for the succeeding year also, and found that the yield was 9 and 10 tons of beets with 15.9 and 16 per cent sugar in the beets for the respective years.

While strongly alkalied and seeped conditions are certainly undesirable, they do not seem to be of themselves the cause of a low quality in the beets, unless so excessively bad that only extreme necessity would justify the planting of the land to this or perhaps to any crop. A further reason for attributing relatively little weight to these factors, alkali and seepage, in this question is that we are dealing with a general condition which involves the whole territory, which is much bigger than the sections in which alkali and seepage may play any part whatsoever, especially in the sense that these are supposed to do injury.

Again the question has been raised whether the quality of the seed furnished might not be at fault. Every consideration of interest and business sagacity on the part of the factories which provide the seed requires us, I think, to consider this as one of the remote possibilities; besides, the occurrence of excellent quality in individual crops produced from the same lot of seed which in general produces beets of poor quality, makes it evident that the fault does not lie in the quality of the seed. Insect injuries are usually so evident that their effects can be easily traced, and while they may at times cause very annoying losses they have not been general during the period mentioned.

The questions pertaining to the effects of fungi are unfortunately very serious—rhizoctonia and phoma on the roots and cercospora or leaf-spot on the leaves. The latter in particular cannot be disregarded. I do not know how we can better answer the question in regard to what is the actual effect of the leaf-spot upon the yield and quality of the beets than by obtaining the record of a larger number of fields which have

been attacked by this disease with varying degrees of severity. The proposition that any agent, whether it be a hail-storm or an attack of a fungus, or whether the leaves be cut off with a mowing machine in July, August or even September, injures the beet and tends to produce a smaller crop and a lower quality will have the assent of almost, if not every one, and yet the facts do not seem to justify this broad conclusion.

I obtained the record of the field samples taken from a field of beets that had suffered severely from the leaf-spot. The actual date of attack I do not know, but it was probably in late July or early August. I was surprised to find that the samples ran from 16 to upward of 17 per cent. The crop was an average one for that immediate section. The beets were putting out some leaves and I do not think that the high sugar-content could be attributed to drying out of the beets. I subsequently obtained the records of 127 fields from various sections of the Valley, obtaining at the same time the character of the soil and notes on the virulence of the attack, and the results are extremely disconcerting and certainly do not justify the conclusions which I had assumed as self-evident. If we were permitted to choose and arrange these results they could be made to prove that the leaf-spot is a very bad, an indifferent, or a good thing. If the 127 results show anything it is that there is a closer relation between the yield and the sugar-content than between the severity of the attack of the leaf-spot and either the crop or quality of the beets. Each section of the Valley has to be considered by itself in this regard. On very vigorous, heavily foliaged beets it is principally the outer and older leaves that are killed. This is in a measure true of all beets, but these outer and older leaves constitute the mass of the foliage and there is often but little left.

The supply of plant food in the soil is, as a rule, fairly good, still there is a question whether the nourishment of the plant may not be deficient or the ratio of the respective foods such as to bring about the results observed.

Experiments have been made with the ordinary fertilizers in various combinations, with wholly inadequate and disconcerting results. The yield was in some cases increased, in others not. The quality of the beet was very seldom affected

in such a decisive way as to indicate any positive beneficial action; on the contrary, many of the results were contradictory. We have, in all, the record of at least 70 experiments. The beets grown on 11 experimental plots have been studied thoroughly, and we cannot discover any good result attributable to the fertilizers used running consistently through the series. So it is very far from proven that the poorer quality of these beets in later years is due to the lack of the ordinary elements of plant food.

The preceding are some of the problems we must consider because they are facts with which we have to deal and cannot evade. We have, however, undoubtedly attributed to them many bad results which they have not produced and have, probably, exaggerated those which they do produce. I think that it is evident that none of these causes are either general enough in their distribution or positively injurious enough in their action to account for the quality of the beets as they were harvested during the seven years specified. In fact, there is no definite proof that has come to my knowledge that any of them produce the specific depression of quality in the beets which prevailed for these years.

The occurrence of remarkable quantities of nitrates in various places throughout the State, outside of as well as in this Valley, suggested the possible connection of this fact with the failure of the beets to ripen up as they had done in former years, and consequently account for the low quality of the beet. If this view should be applicable to the case the question would resolve itself into this: what would be the effect of nitrates supplied to the plants in goodly quantities throughout the season—not at the time of planting nor during the first thirty or sixty days of the plant's growth, but in varying quantities every day of its growth, and even late into the season?

The question is not the usual one relative to fertilizing with Chile saltpetre. If it were we would know what answer to give, namely, that moderate applications, 250 pounds per acre, at the time of planting or during the first thirty days of the plant's growth will produce, according to our observations, beneficial results. Andrlik, however, found no effects produced by the application of 176 pounds per acre, but the ap-

plication of 528 pounds per acre produced prejudicial results. If this application of 528 pounds of sodic nitrate per acre, found by Andrlik to be prejudicial, were mixed with the surface two inches of soil, it would add only 120 parts of nitric nitrogen per million of soil, which is a smaller quantity than we have found in some beet fields at the close of the season. We have found, for instance, in samples taken to a depth of six inches 100, 120, 140 and even 160 parts of nitric nitrogen per million. The last sample indicates the presence of 960 pounds of sodic nitrate in the top six inches of such soil per acre.

As the largest part of the nitrates, if present in the beets at all, should pass into the Steffens waste water, this constituted excellent material to learn whether the beets in general contain any nitrates. This material was found to contain a very easily detected quantity of nitric acid without the employment of any refined methods. Subsequently the molasses and finally the beets themselves were tested and found to contain nitric acid or nitrates. It is stated that German molasses contains very little nitric acid. Bodenbender and Ihlée, writing concerning this point, say: "In addition to the nitrogenous constituents already mentioned, molasses may contain small quantities of nitrates. Two of the samples mentioned later were examined by the Schloesing method, but contained only insignificant quantities of the same, so no determinations were undertaken in the other samples." Ruempler, in discussing Herzfeld and Bode's work, says, concerning the nitrates in molasses: "Nitric-nitrogen was present in such small quantities that it could not be determined."

We found our molasses to be very rich in nitric nitrogen, ranging from 0.30 to 0.47 per cent of the molasses, whereas analyses of foreign molasses which were kindly furnished me showed 0.003, 0.0067 and 0.0082 per cent. Our molasses are evidently abnormally rich in nitrates.

Beets were grown with the application of from one to five treatments of sodic nitrate, applied at intervals of four weeks. The amount applied at each application was 250 pounds per acre. The results were that 250 pounds per acre was beneficial, 500 pounds was not decidedly prejudicial but showed plainly the effect of the nitrate. The larger quantities showed

successively the increased prejudicial effects of this salt. Some of the beets grown on these five plots were worked in an experimental battery, the diffusion juices were carbonated, etc., and evaporated to thick juices. These thick juices showed the presence of from 0.05 to 0.13 per cent of nitric nitrogen. We succeeded in depressing the sugar content from 16.5 per cent to 14.2, or by 2.3 per cent, and the purity of the beet from 83 to 78 and the real purity of the thick juice from 87.9 to 86.4.

A study of the composition of these beets and of a sample of beets grown on ordinarily good soil without the addition of any fertilizer shows very marked differences, but more especially so when their composition is compared with that of good German beets or with that of good beets grown in Michigan or Northern Colorado. These differences are shown most markedly by the amounts of injurious nitrogenous compounds to each 100 pounds of sugar. The good German beets show in the diffusion juice 3.7, approximately 4.0 on the fresh beets, Michigan beets 4.0, Northern Colorado 4.9, beets grown on good soil in the Arkansas Valley 5.6; with the addition of 1,000 pounds Chile saltpetre per acre 14.0, on very bad land in the Arkansas Valley 17.7. A further effect of the nitre is a depression of the phosphoric acid in the beets.

A record was kept of two fields showing the amounts of nitric nitrogen in the soil at various dates and the quality of the beets produced, which I am kindly permitted to use. Field A, March 4, 7 samples varied from 4 to 11 parts per million; June 2, 7 samples from 1.2 to 52.0 parts; June 20, 7 samples from 12.0 to 36.0; June 27, 7 samples from 15 to 130; July 19, 7 samples from 8.0 to 40.0; August 9, 7 samples from 5.4 to 67.0; August 25, 5 samples from 2.0 to 12.0; Beets sampled September 18, 16.2 per cent sugar. Field B on the same dates as given for Field A: March 4, from 6.1 to 20.5 parts per million; June 2, from 4.1 to 112.0; June 20, from 14.0 to 136.0; June 27, from 16.0 to 141.0; July 19, from 6 to 59.0; August 9, from 3.1 to 52.0; August 2, from 47.0 to 333.0. This manner of stating the results gives but a faint idea of the very great increase, section V, for instance, showing on August 9, 6.5 parts and on August 29, 333.0 parts, section II increasing in the same time from 6.5 to 101 parts per million.

The beets on this field were not affected by the leaf-spot. The beets sampled September 18 showed 12.6 per cent sugar. The analyst, fearing that some mistake had been made in determining the nitric nitrogen by the colorimetric method, took another sample, did it both by the colorimetric and Schloesing methods, with a difference of one part per million, samples from these fields were taken to a depth of one foot, and if we take the average of the samples taken from the 7 sections as representing the field on August 9 and August 27, we have the equivalent of 432 pounds of sodic nitrate on the former, and 4,200 pounds or nearly ten times as much present on the latter date.

Either of the above quantities of nitrates present, on these dates, in soil on which a beet crop is growing, is quite sufficient to delay the maturing of the beet, to depress the sugar-content and to increase the injurious nitrogen in the juices.

The Gain in Nitrogen During a Five-Year Pot Experiment with Different Legumes.

By Burt L. Hartwell and F. R. Pember,
Rhode Island Experiment Station.

The ability of legumes to secure nitrogen from the air is now so generally recognized that progressive farmers avail themselves of every opportunity to grow such crops wherever the accumulation or the conservation of nitrogen is of great importance. This has been largely due to persistent teaching, and to the favorable impressions received by those who have followed this teaching, rather than to an abundance of experiments showing the actual amount of gain in nitrogen which results when different legumes are grown. It was to gain more definite knowledge of the extent of the fixation of atmospheric nitrogen that the experiment about to be described was undertaken.

The plants were grown in Wiley pots, 12 inches in diameter and 12 inches deep, made of galvanized iron and covered with paraffin on the inside. The soil was Warwick sandy loam, according to the classification of the United States Bureau of Soils, and contained sufficient fine gravel to make it loose, porous and well aerated. This type represents the lighter soils of the State of Rhode Island.

In brief, the experiment comprised the determination of the amount of nitrogen in the soil at the beginning, in the seeds and water used, in the crops removed, and in the soil at the end of the experiment, in order that the net gain in nitrogen could be ascertained. Cowpea (*Vigna unguiculata*, Walp.), soy bean (*Glycine hispida*, Maxim), white-podded adzuki bean (*Phaseolus angularis*, Willd), and crimson clover (*Trifolium incarnatum*, L.) were grown during each summer, and removed. In all the pots, winter vetch (*Vicia villosa*) was grown subsequently in the greenhouse during each winter and turned into the soil. No nitrogenous manures were used during the five years, beginning in 1906, but optimum amounts of the other nutrients were supplied.

Surface soil, from which the turf and coarser roots and gravel had been removed, was used in the experiment. The manurial additions were made with the object of maintaining a neutral reaction of the soil to litmus paper, of avoiding deleterious residues from the chemical manures, and of providing optimum amounts of all nutrients except nitrogen. In order to know how completely the requirements of the plants for phosphorus and potassium had been supplied an extra amount of potassium was added to one of the four pots devoted to each summer legume, and an extra amount of phosphorus to another.

Before planting the various legumes for the first time, the soil was inoculated with liquid cultures of the appropriate nodule bacteria, to enable the legumes to secure atmospheric nitrogen. These were kindly furnished by the U. S. Bureau of Plant Industry.

The roots of the various crops were examined at the time of each harvest, and at least certain plants in every pot had nodules, although in some instances in the first years not more than two were found on a single plant. As the experiment progressed, however, there was a fair to abundant number of nodules on the different kinds of plants, which furnished evidence that the appropriate nodule bacteria were present.

The summer legumes were planted early in June of each year, and the winter vetch, in the greenhouse, about the close of the same years. The soy bean blossomed during the latter half of July, and the cowpea and adzuki bean during the first part of August; the three crops were harvested when the pods were well formed and before it became necessary to collect many of the leaves, to avoid loss. This was usually during the latter part of August or early in September. The crimson clover rarely blossomed before it was harvested. Early in May, usually at blossoming time, the winter vetch was passed through a meat cutter and mixed with the soil.

In the case of cowpea, soy bean, and adzuki bean, ten plants were left to grow in each pot; and in the case of crimson clover and winter vetch, usually about thirty plants.

The growth of crimson clover was so unsatisfactory throughout most of the experiment, due in part at least to injury by nematodes, that the results are omitted at the present time.

Although principally the clover, and the vetch following it, were affected by nematodes, it was observed in 1909 that the adzuki bean plants in the case of pots 5 and 6, and the vetch which was grown in the same pots during the following winter, made a very poor growth. There was no evidence, however, that the soy bean and the cowpea plants, nor the vetch which followed them, were ever injuriously affected by nematodes. They invariably made a normal healthy growth which had a tendency to increase in amount toward the close of the experiment.

Injury from nematodes is at least unusual in Rhode Island, the development of the organisms being checked by the freezing to which the soil is naturally subjected. In the present experiment, however, as the winter season advanced, the pots were usually taken from the glass house, which served as occasional shelter during the growth of the summer legumes, to the winter greenhouse where the vetch was grown. The nematodes were not, therefore, usually subjected to the ordinary freezing of the soil.

To measure the net accumulation of nitrogen during the experiment, it was necessary to know not only the nitrogen in all material added to and removed from the soil, but also the amount of nitrogen in the soil itself at the beginning and end of the experiment. In order that the latter two sets of nitrogen determinations might be strictly comparable, the following uniform procedure was adopted. The samples were exposed only long enough to become air-dry, and then sifted through a sieve with circular holes about one millimeter in diameter, care being taken that only the fine gravel, but no lumps of soil nor organic matter, was left on the sieve. The amounts of the coarser material, and of the moisture in the fine earth, were determined for each pot at the end of the experiment, and with the help of these data the amount of oven-dry fine soil in each pot was ascertained. The per cent of nitrogen was determined in this soil both at the beginning and end of the experiment, using generally 25 grams for each test and accepting the average of a number of results agreeing within a few thousandths of one per cent. There were about 52 pounds of total oven-dry in each pot.

Considering especially the more vigorous-growing summer

legumes, soy bean and cowpea, the average net gain per pot was 15.07 grams and 17.59 grams respectively. It may be of interest to express the approximate average results with these two legumes not only in grams per pot but in pounds per acre. On the basis of area, the number of grams per pot multiplied by 122.4 is equal to the number of pounds per acre. During the five years there were produced about 400 grams of each of these summer legumes, containing about 11.5 grams of nitrogen. Furthermore there was a net gain of about 4.9 grams of nitrogen in the soil itself.

Expressed approximately in another way, there was a net gain of a ton of nitrogen per acre, seven-tenths of which was removed with the 25 tons of oven-dry summer legumes, and the remainder left in the soil. This was accomplished without the use of any nitrogenous manures, the winter vetch, however, having been incorporated with the soil.

The value of the nitrogen alone would be $320, or $64 per year, if rated at sixteen cents per pound, the lowest price at which the farmer can purchase it in an available form.

These amounts are set forth on an acre basis so that their magnitude may be better appreciated. They should be considered only in connection with the following facts, namely: the soil in the pots was about ten inches deep, which was somewhat deeper than the surface soil in many localities; the winter vetch was grown in the greenhouse; and, furthermore, the plants were supplied with sufficient water.

The Biological Factor in Soil Investigation.*

By J. G. Lipman,
New Jersey Experiment Station.

In dealing with the composition of soils, surface soils and subsoils in humid, semi-arid, and arid regions, we have developed certain facts that may serve as a basis for broad conclusions. We find, for instance, that there is a relative concentration of plant food in certain soil zones; that is, we find that organic matter, nitrogen, and phosphorus are concentrated in the surface soil. We find, on the other hand, that potassium and calcium, that is basic calcium, are concentrated in lower zones.

Now these facts have a peculiar relation to the biology of soils, the activities of the microscopic organisms that are in one way or another concerned with the production of available plant food. As to organic matter and nitrogen we readily understand that these are of atmospheric origin. As to phosphorus we recognize it to be of mineral rock origin, and yet, for some reason, there is a concentration of phosphorus in the surface soil. Otherwise stated, the average surface soil contains more phosphorus than the underlying subsoil. Sulphur would be included in the same class with phosphorus, since there is usually a relative concentration of sulphur in the surface soil.

Let us see what that means in the development of soil micro-organisms, and in the growing of crops, in so far as the latter depend on the preparation of available plant food by the micro-organisms. You remember, of course, that Liebig pointed out with a good deal of force that carbon is constantly circulating between the soil and the atmosphere, that nitrogen circulates between the soil and the atmosphere, and that this circulation is due to the fermentation occurring in soils. A soil devoid of micro-organisms is a dead soil, and as such

*Presented at the symposium on Improvement in Methods of Agricultural Investigation.

practically unfit for the production of crops. In semi-arid and arid regions conditions seem to be somewhat different than they are in humid regions, because of the concentration in the latter of organic matter and nitrogen and also to some extent of phosphorus and sulphur in the surface soil.

You will find also that in humid countries the activities of the micro-organisms are confined almost entirely to a shallow layer of soil, whereas in the semi-arid and particularly the irrigated soils we find various classes of micro-organisms distributed to very considerable depths, perhaps six, seven, or even eight and ten feet. Hence the problem there of the migration of nitrates, and of the accumulation of nitrogen compounds at the expense of atmospheric nitrogen, is a very interesting problem, and in many ways different from the problem as it exists in the humid regions.

Taking the next point: I want to call your attention to the specialization in the functions of soil bacteria. Here we have a concentration of certain materials in surface soils. Here we have the activity of micro-organisms attached to the materials scattered in the surface soil. And we find as we go back to the published accounts of soil bacteriological investigations that we have been dealing for some years with specific functions of micro-organisms. I want to call to your mind, in passing, that in 1877 nitrification, the production of nitrates, was recognized as a biological function; that in about 1880 denitrification, the destruction of nitrates, was recognized as a function of specific organisms; that in the early eighties the production of ammonia in the soil was demonstrated by Muntz and Condon to be a biological function; that only a few years later the fixation of atmospheric nitrogen was demonstrated by Berthelot to be a bacteriological function; that in 1886 we were told by Hellriegel and his associates that fixation of nitrogen by legumes was a biological function. Thence we pass on to the isolation of nitrogen-fixing bacteria, by Winogradski, in the early nineties, and of another group by Beijerinck in 1900.

All of these were discoveries of specific organisms doing specific work in soils, important to the well-being of higher plants. We have thus been studying soil bacteriology from the standpoint of specific functions for many years. These

studies were necessary, for we must do analytical work before we can do synthetical work, that we might understand the simpler phases of micro-organic activities in the soil.

We have been dealing, therefore, with certain of these specific functions in the cleavage of nitrogen compounds, the oxidation of ammonia or nitrites, and the hydrolization of cellulose, decomposition of fatty acids, etc. These are all specific processes. But while we have recognized that there are certain organisms doing certain things, we have not exhausted the field. There are other organisms still to be discovered doing other specific work of which we are not yet aware, so that there is evidently much research to be done; but at the same time we are ready to proceed in a broader way to study the larger problem in so far as the algebraic sum of the bacteriological activities will give us information as to the possibilities of any soil for crop production.

Botanists have been studying ecology, the natural selection among certain plants and forest trees, as affected by climate, soil, and geological formations. We do not know, if we are to be candid, whether there is a definite soil flora. Is there a certain combination of species in every soil? Is there a more or less defined relation between different species in certain soil types? Is there any relation between soil flora and the chemical or the mechanical composition of soils? Is there any relation between climatic conditions, certain climatic conditions, and soil flora? We do not know.

Now, while the classification of soil bacteria would not be the highest kind of bacteriological work—at best but slow, tedious, thankless work—there is yet need for a number of men in different portions of this country and in other countries to take up the study of soils and their bacteriological analysis, so that we might know what are the prevailing types of soil organisms. This is now being done in a small way, and I feel that it will be done in a larger way as the equipment and facilities for that work become more adequate.

Then we feel that, while we have recognized micro-organisms as having specific functions, we do not know how these specific functions are modified by the composition of the soil itself. Of course, we may say, "Here is an organism that will produce nitrates; here is an organism that will fix atmospheric

nitrogen." How are these affected by the soil, by its varying moisture content, by tillage operations modifying aeration or the distribution of organic matter? We do not know. Here is a large field for future work; the study of the physiological functions of bacteria, bearing on crop production as they are affected by the character of the soil itself, chemically, mechanically, as well as by the climatic conditions.

Then, in how far can we modify the activities of soil bacteria to suit our needs, to suit the necessities of the crop, by modifying the soil environment? Remy, for instance, has done some work along this line. We have done some work along this line in New Jersey. Some work has also been done elsewhere. But we are at the very beginning of knowing how we can utilize soil organisms in an economic way for better production, more profitable production, of crops by changing the soil environment, whether that be moisture, aeration, temperature, reaction, amount of organic matter or character of the organic matter.

Then we come to the sum total of the biological activities, or, rather, the expression of those activities taking the soil as a whole. We speak of the nitrifying power of the soil, the ammonifying power of the soil, the reducing power of the soil, and the oxidizing power of the soil. We consider the various species acting and reacting on one another, and we try to find the expression.

Let me illustrate: We have methods that are based on the same principle and carried out in the same way. Solutions are made up that would allow the growing of certain kinds of micro-organisms. For instance, suppose that I wanted to study the so-called nitrogen-fixing bacteria, those bacteria that can transform elementary nitrogen into nitrogen compounds. We should then make up a solution that will suit the development of these particular organisms, and should judge by the amount of nitrogen fixed as to the ability of the soil from which the organisms came to fix atmospheric matter.

In other words, we make up a culture medium and inoculate that culture medium with organisms from different soils, and compare in a systematic way the physiological functions, whether it be ammonia production, nitrate production, or nitrogen fixation of different soils. For all that we must

admit that liquid culture media are not natural media. There has been a tendency of late to go back to the soil itself and to use it as a culture medium for determining the relative rate of transformation or fixation of nitrogen. In this manner we try to find an expression of the bacteriological function of soils, their ammonifying power, nitrate-producing power, and nitrogen-fixing power.

Now, as to the next point, which I wish to discuss particularly, since the other points are merely preliminary. We have already collected a mass of information on soil organisms. We all agree that they are as essential in crop production and soil fertility as are other important factors, but we do not know how to proceed to secure the information that we wish to obtain. How are we going to obtain it? Of course we can count the number of bacteria in any given soil; indeed that was the earliest work in soil bacteriology, or at least a part of the earliest work. But we recognize that the knowledge of numbers in soils is often of no greater service to us than the knowledge of numbers of bacteria in milk. It is only occasionally that this knowledge has a certain relative value.

Again, we can study organisms isolated from different soils, organisms of certain types, and can compare them as to their ability to do the work that we think they are doing in the soil. This would correspond to the comparison of different strains of cereals or corn or potatoes as to yield. But even this method is not entirely satisfactory. The truth is, we are in need of methods that will enable us to measure in a more exact way the biological functions of soils, just as we can measure the chemical functions of soils or the physical properties of soils. A chemist will analyze a sample of soil and will tell us that the plant-food content is so and so—so much nitrogen, so much calcium, so much phosphorus, or so much potassium. We shall then know to what extent we could draw on the plant-food resources of the soil. Similarly, the soil physicist will advise us as to the texture of any particular soil and will tell us that under certain conditions we could grow market garden crops, hay, cereals or any other crops in so far as they are affected by soil texture.

Now bacteriology gives us some information as to the biological functions of any given soil. In this case, however,

we encounter a serious difficulty since we are dealing with micro-organisms, with living things, that are far more changeable than the physical or chemical factors. Hence it has been our endeavor at the New Jersey Experiment Station to differentiate as far as possible the bacteria on the one hand, the organic matter on the other, for it is the decomposition of the latter that is used as an index of the activities of the former. In other words, one of the first steps in the study of soil bacteriology from this broader standpoint of creating methods is to know in how far the organic matter of any soil will be a suitable food for the micro-organisms of the soil.

Differences in the availability of organic matter in soils are as pronounced as they are in that of fertilizer materials. We know, for instance, that different samples of dried blood used as a fertilizer will not give us the same returns when used as a source of nitrogen for crops. We know that different sources of phosphorus will not give us the same results; and we estimate those differences as relative availability of plant food. Now if we could go to work and take the organic matter out of a series of soils and keep that organic matter under standard conditions and let a uniform bacterial material, whether it be of the same species or different species, act on that organic matter and cause its decomposition, we might be able to determine the relative availability of that organic matter as a source of bacterial food. There is the germ of an idea which has already served us in a small way, and is certain to serve further as a basis for the study of the biological factors of soils.

Let us take organic matter from different soils and under standard conditions compare the rate at which that organic matter may serve as a food for micro-organisms. Let us take, on the other hand, the organisms themselves, that is, an infusion from any given soil, and compare that with an infusion of another soil, to see how the bacterial factor, as apart from the chemical factor, is more or less a constant in any particular soil. The changes produced could be measured either from the carbon standpoint or from the nitrogen standpoint. And it seems to me that the study of the decomposition of organic matter in soils, the study of the biological factor of soils, from the carbon standpoint, has fully as much promise of yielding important results as the study of the

decomposition of the organic matter of soils from the nitrogen standpoint. Some work has been done along that line. We have been doing work for the past two years at the New Jersey Station on the carbon-nitrogen ratio of organic matter in soils.

Somewhere in his book Hilgard says that if humus—I believe he uses the expression "humus"—that if soil humus contains less than 4 per cent of nitrogen it seems to be unable to furnish available nitrogen compounds to crops with any degree of satisfaction. In other words, we must expect a certain amount of concentration of nitrogen in organic matter if the latter is to yield the necessary amounts of nitrogen compounds to growing crops. You will remember his work on the proportion of nitrogen in humus from different soil zones of the United States with reference to humidity or aridity. Professor Jaffa is here and he can bear me out on that. You will find marked differences in the composition of the organic matter derived from different soils.

Now, in our work with soil bacteria we find that by modifying the proportion of carbon compounds, that is, of non-nitrogenous to nitrogenous compounds, we can modify materially the decomposition processes. For instance, we may mix dried blood with a given quantity of soil and expect that a certain amount of ammonia will accumulate as the dried blood undergoes decomposition. If we add sugar to the dried blood we shall find that ammonia does not accumulate in the soil. Bacteriological examination will show at the same time that the number of bacteria has increased enormously. In other words, the sugar does not stop the multiplication of the microorganisms but does stop the accumulation of ammonia.

Properly interpreted, the facts in the case show that the production of ammonia is not discontinued, but that the ammonia is transformed as rapidly as it is produced into more complex compounds. In other words, there is a balance somewhere in the soil in the decomposition of organic matter and a certain amount of competition between the higher plants or crops and the bacteria. We often have certain soil troubles, certain undesirable conditions in the soil, not because there are not enough bacteria in the soil, nor because there is not enough bacterial change in the soil, but because the bacteria

act as competitors to higher plants and rob them of soluble nitrogen compounds or rob them perhaps of soluble phosphates or sulphur compounds. We do not recognize this fact as we should.

From what I have said you will note that we can compare the bacterial functions of soils apart from the functions of the organic matter in these particular soils. Moreover, we can compare these functions either from the carbon standpoint or from the nitrogen standpoint. We may estimate bacterial action by the rate of ammonia or nitrate production or by the rate of carbon dioxid production. This may be accomplished in the laboratory with small quantities of soil, or on a larger scale in the field itself. I am willing to predict that we shall find the rate of carbon dioxid production, that is, the rate of oxidation of carbon in soils, a very useful measure of the biological processes in the soil, in so far as they bear on crop production. We shall thus study the effect of lime, manure, rotation and fertilization as indicated by the amount of carbon dioxid evolved from soils under similar conditions.

These, in brief, are the methods that we are now using and that we shall use in the future in gaining a broader conception than we now possess of soil bacteriology. We shall come to study the biological function as the expression of all of the bacteriological activities, rather than devote most of our time to the study of single species and the particular kind of work hose single species are doing.

The Feeding Experiment—Its Improvement and Refinement.*

By H. J. Waters,
President, Kansas State Agricultural College.

As with the old recipe for cooking the hare, which began "first catch your hare," so with the solving of nutrition problems, first get your problem.

The project should relate definitely to some fundamental problem of wide application and large economic importance. I strongly advocate the policy of selecting some definite and particular thing to do, for it is only by attacking one detail at a time that we shall get definite results, but this detail should be a part of a large and important problem. The whole problem should be thought out before any detail is taken up for study. Moreover, it should be a problem with a to-morrow as well as a to-day. It does not matter what its yesterday was, or indeed whether or not it had one. Its historical significance is of little consequence. Its present and future significance should be the determining factor.

Thus far in our experimental work we have been merely interpreting the practices of the farmer. He has been the leader and has determined the trend of agricultural practices. If the colleges and stations are to fulfil their highest purpose they must be the leaders as well as interpreters. This means that in planning an experiment we must take a look ahead and, as accurately as possible, determine what the practices of the future should be to be most rational, and work out the problems that need to be solved before this practice is possible. Ideas are scarcer and more to be desired than funds. The experimenter who is fortunate enough to have unearthed a problem of real practical and fundamental significance is fortunate indeed.

After deciding upon the problem, the next step necessary is to think it out. We should remember that no man can

*Presented at the symposium on Improvement in Methods of Agricultural Investigation.

experiment more clearly than he can think. If he is hazy in his thinking he will be bungling in his researches. If a contemplated project does not clear up and fall into definite shape by the time one is ready to begin it, it will be well indeed to postpone its inauguration until such time as it does clear itself.

Put the question in such a way as to compel a clear and definite answer so that data of significance will be the result. Formerly it was regarded as the proper thing to gather data even though the data had very little significance. To accumulate data merely or chiefly for the sake of accumulating them, and regardless of the use to which they can be put, is about as illogical as to have contours run on one's field, and an accurate map of the same made showing all the depressions and slopes, when the field is neither to be drained nor irrigated. Doubtless such a survey would develop many very interesting and quite surprising facts, but they would be of very little value.

MUCH PRELIMINARY STUDY REQUIRED.

It would seem needless to urge the importance of the careful planning of an experiment before it is begun. Nevertheless I am convinced, from long experience, that comparatively few projects are planned in sufficient detail before they are begun.

To plan wisely it will be necessary to know accurately and in detail what has already been done along this and related lines. It will be necessary to know what the teachings of pure science are on this point. It will be well even to ascertain whether the teachings of pure science in this particular are based upon definite experiments or are merely traditional.

Of equal significance, and too frequently entirely overlooked, is an accurate, first-hand and up-to-date knowledge of the practice of the most intelligent farmers of the country in the field sought to be covered by the experiment. The investigator who disregards the general and well established practices of the farmer, on the theory that they are apt to be unscientific and as apt to be wrong as right, is making a serious mistake. The farmer is a very acute observer. Generally speaking, he has not been eminently successful in

interpreting his observations and correlating his facts, but he has a large mass of facts of too much importance to be overlooked in planning a line of investigation that seeks to refine and improve his practice. The investigator, therefore, may lay too much stress on the farmer's theories, but his facts are entitled to very careful consideration.

The preliminaries to the planning of an experiment are, therefore, very large and require much time. No greater mistake can be made than suddenly to be seized with a conviction that a certain line of work would be advisable, and straightway to go and begin it.

In some instances there is danger in too much preliminary study. One may by this means get so close to the problem as to lose perspective. He may become so confused with the multitude of details that he will lose sight of the main problem and seize upon one of its minor details. He may be so overwhelmed by the mass of information gathered in this preliminary study that he will conclude that the field alraedy has been covered and that no problem really exists.

In other cases he may have the matter so worked up into theories in his own mind that his judgment will be warped in planning the experiment, or in the deductions which he will draw from his data when the experiment is completed. Obviously, these defects are personal and the remedy lies wholly with the individual. If he has not sufficient clearness of view to avoid the first three difficulties enumerated and has not enough intellectual honesty to avoid the fourth, he is unfit to plan and conduct experiments.

THE CONVENTIONAL FEEDING EXPERIMENT YET HAS AN IMPORTANT PLACE.

There is yet plenty of need for the conventional feeding experiment, involving primarily a comparison of different feeds, in different combinations and in varying amounts, when fed to animals of different breeds and ages and in different conditions, etc. It is only by this means that we can determine how to feed, what to feed, and how long to feed. It is the only way by which we can determine the application of the results of fundamental experiments to farm practice. There is no royal road to this knowledge, and no shorter cut

than actual trials with the kind of stock the farmer has to feed, and under the conditions prevailing on the farm.

After all, this is the large work of the stations for the next generation, at least. But along with this should go, in all of our stations, some really fundamentally work. It may, with proper planning, form a part of this so-called practical or commercial work. With the Adams fund available, the stations cannot plead lack of funds for the fundamental work.

KEEP A CHECK ON WHAT HAPPENS.

Even in our commercial experiments, we must have a better knowledge of what happens than our present methods afford. To illustrate: At Missouri we thought we could see a much more marked tendency in young cattle, calves, and yearlings to grow instead of to fatten when the protein deficiency of corn and blue grass pasture was supplied in the form of gluten meal, than when linseed meal was the source of the extra protein. Cotton-seed meal was more nearly comparable in this respect with gluten meal than with linseed meal. But in the case of more mature cattle, well-grown two-year-olds, and especially three-year-olds, cotton-seed meal appeared to fatten the animals more rapidly than either of the other meals.

If these are facts, they are very important to the feeder. Also, it is important to know why these feeds have these specific effects. Manifestly the first thing is to ascertain if they have such influences. Slaughter tests with proper chemical and histological control will answer this question definitely, and without very great expense beyond that required to conduct the ordinary commercial feeding trial.

I mention this wholly by way of illustration of the importance of determining as accurately as possible what takes place, growth or fattening, and in what proportions these processes occur, and not to suggest this as a problem to be undertaken. Only by this means shall we be capable of accurately interpreting our data.

SEVERAL DEPARTMENTS MUST WORK TOGETHER.

The animal husbandman must be content to share the plan, the work and the credit with other departments of the station. The besetting sin of the present organization of the experi-

ment station, and the cause of much of our superficial work, is the unwillingness or incapacity of our men to combine themselves into a team and attack a problem as an institution, rather than as an individual or as one small department of the institution.

We complain much of the lack of cooperation between the different experiment stations of the country, and between the experiment stations and the United States Department of Agriculture, but the failure of our stations themselves to work as a unit on a large problem is a source of even greater waste of effort and funds. Human nature, unfortunately, is so constituted that frequently it is easier to arrange a cooperative effort between two stations than between two departments or divisions of the same station. This comes about largely through the looseness of our station organization, and particularly through the attempt to make of each department in a station a distinct entity and to draw sharp distinctions between the functions and work of each. We constantly are seeking the lines of cleavage between departments of the station when we should be seeking the means of knitting them together into one whole. The latter is the modern practice of well-organized team work, the former ancient and inefficient individualism.

A necessary prerequisite to a refinement in the methods of work will be to have the help of the chemist, the physiologist, the histologist and the zoologist in planning as well as in carrying on the investigation. Heretofore the chemist's part in our feeding experiments has been of too perfunctory a nature.

MAKE THE PLAN IN DETAIL.

An experiment should be planned in the minutest detail before it is begun, and it is needless to say that every part of the plan should be written and criticised by everyone in the institution, and out of it for that matter, who is likely to be able to throw any light on the problem. In its final form it should show:

1. The object of the experiment, clearly and fully set out. It should show what scientific and what practical problems are sought to be solved. Of course involved in this is a statement of the need for such work.

2. A detailed discussion of the present practices, covering as wide a range as possible, and classified as fully as possible.

3. A statement of the teachings of pure science on this point, and a summary of the standard current theories relating to the subject. As already stated, the practical man's theories should be included as well as a discussion of what is the current practice.

Here if the experimenter desires, and I count it important, although opinion on this point is likely to differ widely, he might carefully set down a forecast of the results of the experiment, and what the true principles underlying the problem are. The only value this can have is to assist in clearing one's mind, and anything that will help in this direction is highly to be desired.

It is very important to incorporate all this information in the plan because the author of the experiment may die or leave the institution before the work is completed. And even if the station is fortunate enough to claim his services until the work is finished, it is important to have it on record while the matter is fresh in the author's mind.

It should be remembered that the officer in planning the experiment has or should have used a considerable amount of time for which the station has paid him. Oftentimes, too, there have been other expenses, as of travel, salaries of assistants in looking up literature, or visiting farmers, etc. The station is entitled to have the facts and conclusions growing out of these studies set down for any use that may be deemed desirable, and the officer has no more right to refuse or fail to make them available and in permanent form than he would to fail or refuse to record the results of the experiment itself. Indeed, the results of the studies preliminary to the beginning of the experiment are an important part of the record, and should be as carefully set down and preserved as any of the data in connection with the problem.

4. The methods of carrying out the experiment should be set down in the greatest detail, and with the utmost clearness. It should include, among other things, detailed directions regarding the selection of the animals, the rations to be fed, the routine of feeding, weighing, sampling, the disposition of the aminals at the close of the experiment, the exact data to

be recorded, the method of making the records, what to photograph and when, what measurements to make, etc.

In short, nothing required to be known by one entirely unfamiliar with the plan or purpose of the experiment, to enable him successfully to carry it out, should be omitted. This is important for two very excellent reasons. It furnishes a definite guide to the assistants in charge of the experiment, and will on that account serve to prevent many errors at the barn or in the laboratory. Moreover, nothing is so helpful in clearing one's own mind in respect to the matter in hand as the definite and detailed planning of precisely how the experiment is to be carried out. If the plan involves the cooperation of other departments, such as the chemical, histological or physiological, the exact nature of the work required of them, at just what stage of the experiment it is to be required, etc., must be clearly set forth.

Then, as a final chapter, there should be given a systematic bibliography of the subject, with full and accurate references to all the literature, which literature, it is needless to say, the author of the experiment should be familiar with.

It may be said that all these things will make a volume. The larger the better; the more detailed the plan and the greater the care exercised in making it, the better the outcome is likely to be.

Needless to say a complete copy of the plan should be filed with the director of the station, who should have had an opportunity to criticise it in its various stages of development, and also with each officer and assistant who is to have any part in the work.

CARRYING OUT THE PLAN.

It should not be understood that even all this care in planning the experiment will materially lighten the later burdens of the investigator. Indeed one of the worst things that happens to an experiment is for the man who planned it to leave its execution entirely or even largely in the hands of an assistant, no matter how competent the assistant may be.

The statistical data are not the only data required, and are by no means the only important results of an experiment, and one who must rely solely upon these cannot hope to get

all out of an experiment that it ought to teach. The man in charge should see the animals at least once each week, and should have the opportunity on the occasion of these inspections to study the results thus far attained in connection with the appearance and behavior of the animals. I know from years of experience that this is very important in feeding experiments, and doubtless it is just as important in the field crop experiments.

Personally, I prefer to study the animals before I see the data in order to see if I can ascertain from the appearance of the different lots how they are thriving. If my own judgment is confirmed by the figures then I feel all the more convinced. But this is a minor detail.

KEEP THE RESULTS COMPUTED UP TO DATE.

In order that they may be available for study at each week end or when the author of the experiment visits the pens or barns, the data will need to be calculated as the experiment progresses.

Certainly no experiment should be repeated until the data of the previous trial have been carefully studied. For this reason I am, after many years of advocacy of the opposite plan, a strong believer in the wisdom of publishing the results of a single experiment as soon as it has been completed, together with such tentative conclusions as seem to be warranted. The main advantage in this plan is that it will insure the computation and study of the results of one experiment before the plan of a subsequent trial is decided upon. Of course, expenses may be saved by omitting the publication until the results of several trials are available, provided each trial is calculated and the data are carefully studied. But the danger is that they will not be computed and studied as carefully as if they are immediately to be published.

I realize, of course, that all this is ideal and in practice can at best be but approximated. It should, however, be the constant endeavor of every investigator fully to live up to these requirements.

Methods in Nutrition Investigation.*

By E. B. Forbes,
Ohio Experiment Station.

It is not my intention to discuss this subject in a general and exhaustive way, but on account of the greater weight of personal evidence to limit this paper to my own experience in the solution of specific problems.

The field of my investigations is in general the specific effects of foods, and in particular the functions of the mineral elements, in animal nutrition, especially in growth. The plan of our present program is to compare the nutritive values of pure compounds of phosphorus added to a standard basal ration, and then by a study of the phosphorus compounds in foods, to judge of their nutritive values, and to learn the reasons for certain of their specific effects when fed to growing animals.

The experiments which we have thus far conducted have been with swine only, the processes to be described have to do especially with swine, and our methods of handling the carcasses have been evolved for the purpose of making possible a complete chemical accounting for a considerable number of swine at one time.

Our experimental program embraces two general lines of work: metabolism experiments, involving observations on food, urine, and feces, and feeding experiments in which the principal work is done on the carcasses of the subjects. Neither the metabolism experiment nor the ordinary feeding and carcass experiment alone can tell us all that we need to know. Both have their strong points and their imperfections and must go hand in hand. The metabolism experiment cannot practically be made sufficiently extensive to eliminate the factor of individuality, not sufficiently protracted to give valuable results on growth. The routine is at best trying to the subject of the experiment, and the extent and nature of the

*Presented at the symposium on Improvement in Methods of Agricultural Investigation.

influence of these unavoidable discomforts on the results of the experiment must remain matters for speculation. In this case the results are in the end indirect. Such nutrients as we cannot account for we assume that the animal has retained, and just what he has done with them we are unable to say.

The more extensive feeding and carcass experiment is in many ways a better method for the study of problems in growth. It may be made as extensive and as protracted and as accurate as you please, and you may get direct weights of your experimental products in hundreds of pounds or kilograms. One weakness of this method is that it is difficult to prevent the animals from getting food other than that administered, even though you confine the animals to paved lots and use planer shavings for bedding as we do. Pigs eat even these planer shavings to a certain extent, and when they begin to experience a real shortage of organic phosphorus they will eat their own feces, and thus provide for a continuous circulation of the indispensable material. I see no practical way to prevent this but to muzzle the pigs.

After conducting one metabolism experiment we discarded the idea of a harness for a pig, not as impossible, but as unnecessarily inconvenient. We can do better. Our next attempt was with a small digestion crate in which the animal was closely confined, except when liberated for exercise. Experience again pointed the way to progress, and we evolved a large crate which allows entire freedom of movement of the hog and still provides for the accurate collection and separation of urine and feces.

We have had difficulty in the feeding of our low-phosphorus basal ration of pearl hominy, wheat gluten and blood albumen because of its highly digestible character. The pigs became constipated, the feces deficient in amount and so black that they were difficult to mark, and the defecation became irregular. These troubles were obviated by the use of ground corn bran to give bulk to the feces, carmine as a marker, and pulverized agar-agar as a laxative.

I believe that very general improvements should be made in the selection of animals for nutrition investigations. We do not habitually give full weight to the consideration that the

value of an animal for such a purpose is affected by a great number and complexity of obscure and inaccessible processes and agencies. In order to get evidence on this point, I selected 9 lots of 5 pigs each of the same breed, and having had the same previous treatment. They were then fed all of them on the *same* foods, with a view to determining the limits of error in such work. It was found to be very considerable. As a result of this test we now use in our experiments tested animals only. Every animal used is given a preliminary feeding in which he is made to prove his fitness for further work. Only such animals are used in comparative experiments as have been proven to yield the same results, within satisfactorily narrow limits, under the same conditions of management. In consideration of the great prominence which recent development of live-stock judging has given to the individual differences which exist among animals, it seems quite as unwarranted as it is unnecessary for us to continue to assume in advance of its proof that animals which look alike are functionally alike.

We have pens for individual feeding and through their use we so select our experimental lots that the animals in each have on the average made an identical preliminary record. Then we begin our experimental work by killing one of these tested lots as a basis for comparison, their carcasses being put through the entire series of observations to be made on the remaining lots at the close of the experiment.

Our chemical methods generally are so unspeakably crude in comparison with the life processes which we wish to study that we must give the chemist every possible advantage that may be derived from a rigid and thorough preliminary test of our experimental subjects. A whole series of chemical changes proceeds with advance in age, including even so easily determined a constituent as moisture, and in as important an organ as the brain, and hence if the carcasses are to be subjected to critical chemical study the age of the animals should be known and considered in the make-up of the experimental lots.

It is, of course, essential that animals for nutrition work should be bred and reared under known conditions and with especial reference to the object in view. If it takes three generations to produce a gentleman, it takes no less to produce

the desired degree of uniformity in a herd of live-stock to furnish subjects for nutrition investigation.

In regard to the matter of individual records my position is that it would be desirable to have individual records all through the feeding and analytical work, and that it is desirable in using averages that we know all of the figures contributing to the average, in order that no abnormal figures may be included; but as a practical measure I believe that after proper individual preliminary test of experimental subjects, thus ruling out the probability of the inclusion of abnormal individuals, the advantage of numbers as minimizing the effects of individuality fully warrants the compositing of the several carcasses from one experimental lot for chemical analysis. Our program at the Ohio Station would be impossible on any other basis.

In connection with our work on phosphorus compounds an idea has come to me which I wish to suggest for your consideration. May it not be that an animal posseses capacities which it uses *in extremis*, when sorely pressed, which it has not or does not use in normal states of nutrition? Some of our observations are difficult of explanation on any other basis. Let us proceed with caution in applying to the practical feeding of dairy cows results obtained on a starving rat in a glass jar.

After several years' experience in the conduct of slaughter experiments at packing houses, large and small, the impression resulting from my first attempt has grown even more decided, that the packer is not equipped for nutrition investigation, and that it is not practicable to obtain satisfactory data and materials from such an establishment. On this account we have constructed at Wooster a building for nutrition experiments, which I believe will admirably serve our requirements.

The building is 40 x 60 feet on the ground, with two stories and a high basement. The lower floor contains our refrigerating plant, consisting of a 20-ton ice machine driven by a 40-horse-power motor. We have also in this room a tank for making ice. On this floor is also our machinery room, in which we have a rendering outfit, feed, meat and bone cutters and grinders, facilities for removing fat from pig skins, and a testing machine for breaking bones. On the floor above is the

killing room, with equipment for hogs, sheep and cattle; and also the coolers, four in number, piped for various temperatures, and occupying a space about 20 x 40 feet on the floor and 15 feet high. The top floor is occupied by an animal experiment room for metabolism work, a feed room, physiological laboratory, office and attendant's bedroom. Our chemical laboratory is in another building.

In our killing process it has been customary to stun the animal before bleeding, but this clots the blood in the brain so that it is very difficult to prepare it for analysis, so we devised a rack for holding the hog while he is struck without stunning, the blood being put into a friction-top pail which accompanies the hog and receives the remainder of the blood during the dressing. The hog is scalded quickly, and any such hair as is lost is the scalding is caught by a removable copper-wire screen lining to the scalding vat. The hog is scraped on a segment-top bench covered with a copper-wire screen to catch the hair.

Throughout the killing expedition is the rule, and each separate part as it is removed from the carcass is put into a weighed and labeled friction-top can or pail which is set at once into the cooler, but a few feet distant. The weighing is mostly done at comparative leisure after the slaughtering is concluded.

There are several reasons for haste in getting the animal killed, cut up and into the cooler: first, to prevent evaporation; second, to keep down chemical change, and third to forestall translocation of liquids within the body. If the brain is not removed immediately after killing there is an appreciable amount of absorption of water, and along with it who knows what else? There is also reason to anticipate the demonstration of an increase in inorganic phosphorus in the tissues immediately after death, but we have found this a difficult point upon which to satisfy ourselves on account of analytical troubles due to the sampling of the meat before *rigor mortis* has occurred. The best that we can do to prevent these undesirable changes is to use haste, friction-top pails and refrigeration.

We have not yet attempted to prevent loss of moisture from the carcass by covering it before it has cooled out, but are pre-

paring to do so by the means of packer's waxed paper bags at our next killing. The difficulty here will be the interference with the cooling of the meat, but we hope that this may be controlled by varying the temperature in the cooler, and governing the same by the use of thermometers in the meat. We have already used this method with fresh hams with success. If we had two shifts of assistants, one to work days and the other nights, we might proceed to work up the carcasses at once without cooling. But our help is limited and we find it advisable not greatly to lengthen the working day in such a program. It is easy to devote one's self so closely to such absorbing work that after a time he suddenly becomes conscious of a feeling that all this world is hog meat, and that he is mortally sick of it, which greatly lessens his efficiency.

It is important that tissues should not be frozen previous to preparation for analysis, on account of the ruin of their structure, the liberation of liquids, increased difficulty in sampling and increased tendency to enzymatic and bacterial disintegration. After the preparation of the sample, however, we immediately freeze the ground meat at 12 to 15° F. below zero and keep it there till we are ready to weigh out for analysis. The bloods are coagulated by steaming and are then easily ground and sampled, just as are the solid parts of the carcass. This process would interfere with observations made by some other workers in this field. A weight before and after steaming and the incorporation with the material of condensed moisture on the inside of the pail prevents error and is easily accomplished.

We use a small electric grinder for small parts, and a large belt-driven meat cutter for the first and second grinding of the larger samples. These latter are ground out on to an aluminum-topped table, thoroughly mixed, and a 20-pound sample taken from this for further reduction in a "Buffalo Silent" cutter in which the meat is cut by two knives revolving thirty times each a second, and is thus reduced in a very few minutes to a smooth paste of uniform color and texture. It takes a shearing action to cut hog hair. This is best accomplished, strange to say, with the nut-butter attachment of a meat chopper. Hoofs will not grind fresh, but after treatment in an autoclave can be run through a meat chopper, and the

coarse meal resulting therefrom grinds nicely in our Krupp sample mill which cuts with interlocking steel burs.

Certain tendons I consider it safest to weigh with the muscles and then to discard. They analyze enough like muscle so that they may be rejected without appreciably affecting the percentage composition of the very considerable mass of flesh, but do not analyze so much like muscle that it is safe to risk including chunks of considerable size in small weighings for analysis. These tendons may be handled fairly well by inclusion in a miscellaneous sample containing skin and cartilage.

Half of each carcass is analyzed in 10 samples, which is as great a number as we can handle and use several lots of animals at a time. The other half is shipped to a small packer. In removing fat from the hide, strips of the latter are held in a remodelled clamp of a harness maker's horse, and the fat is readily removed as clean as you please with a butcher's block scraper ground very sharp. We have a smoke-house connected with the building and will cure meats when we get a little further into our program. In studying the breaking strength of bones we use a testing machine made by Tinius Olsen, and especially adapted by the manufacturer to suit our requirements. It registers automatically by $\frac{1}{2}$-pound intervals.

A few points in our chemical methods are perhaps worthy of mention. An accurate moisture determination is of course fundamental to meat analysis. You are doubtless aware of the inevitable errors in moisture estimation on either plant or animal products, when made by heat, either in air or in hydrogen. Our moistures are all made in vacuum desiccators over sulphuric acid without heat, by the Shackell method. The finely ground meats are weighed by difference into porous earthenware extraction capsules, where they are mixed with washed sea sand, then frozen, put into desiccators and dried from the frozen condition without melting. The ice crystals wedge apart the tissues and on evaporation leave them in elegant shape for extraction, and the freezing is also necessary to prevent the frothing of the more liquid tissues during the exhaustion of the air.

Alcohol and ether extractions are made on these same samples in the same capsules, and after once using they may

be cleaned by burning in a muffle furnace. Moistures on foods are made in friction-top aluminum dishes in the same vacuum desiccators. Crude fiber on foods we do by Morgan P. Sweeney's new method, but we modify it by conducting the filtration, washing and ignition all in a porcelain Gooch crucible without transfer, filtering through very fine white glass-sand on asbestos. Coarse sand will not serve this purpose, but solutions which are almost impossible of filtration by any other method will run through this sand and asbestos filter very nicely.

I believe at the present time the crudest chemical determination in general use, next after crude fiber, is the use of ether extract as a measure of fat. After several months of comparison and study of various extraction methods we have discarded them all, and have provisionally adopted Kumagawa and Suto's method, which begins with a direct saponification of the whole fresh tissue and ends with a direct weight of fatty acids.

In our work both with foods and animal products we have occasion to separate and to estimate the groups of phosphorus compounds contained therein. The most important of these distinctions is of organic from inorganic compounds. We have published two methods for this determination, one for animal and one for vegetable substances. The points of our method for animal substances are extraction with hot ammonium sulphate solution, filtration through sand on linen, and a preliminary precipitation of the phosphates with magnesia mixture previous to the usual phosphorus estimation.

In vegetable substances our problem was to evade the interfering action of nucleinic acids, phytates and other compounds on the precipitation of the phosphates, without decomposing phosphorus-containing organic bodies. This is accomplished by a preliminary precipitation with magnesia mixture, nucleinic acids remaining in solution, and dissolving the phosphates out of the precipitate, which contains phytates, by the use of acid-alcohol, in which phytates are insoluble.

Lecithin we have determined by two methods, both in principle being phosphorus estimations on refined alcohol-ether extracts, in one keeping inorganic phosphates out of the extracts by the use of anhydrous reagents, and in the other

extracting with ordinary crude reagents and freeing from phosphates by emulsification of the fats and solution of the salts with acid chloroform water. The former method, using anhydrous reagents, is the more accurate of the two.

We are equipping on a large scale, with specially constructed apparatus, for a further separation of the groups of phosphorus compounds by a modification of the general method of Plimmer and Scott. This seems to us to be the most promising method out, since it rests on a careful quantitative investigation and is the only one known to me which is workable on a routine basis. In principle it consists of phosphorus estimations on specially treated extracts with alcohol, ether, 1 per cent hydrochloric acid and 1 per cent sodium hydrate, and gives us figures for lecithin, inorganic, nucleic acid, nucleoprotein and phosphoprotein phosphorus.

In critical studies on growth or production of other increase it is impossible for us longer to ignore the mineral nutrients, both individually and also in the relation of the basic to the acid mineral elements. These considerations are often of first-class practical importance in the commonest way, and if they do not touch us otherwise are very apt to do so in the rearing of our own babies. In this work we have made inorganic analyses of all the common foods of man and the lower animals.

One sweeping criticism can with justice be made of my work and also that of many of my acquaintances in this field. I will confess for the whole crowd. We are piling up great quantities of more or less accurate data which from their very nature are often impossible of interpretation, and some of which do not give promise of ever contributing generously to the solution of nutrition problems. The crying need is for more *significant* observations. Some of our records which we are at present unable to use will doubtless be understood in time, when the rest of the pattern of which they are a part shall have been worked out, but still I maintain that some of our programs of experimentation are too much like the western rain-making demonstrations of a few years back, and that we should strive to add point, directness, significance to our plans. Instead of striving to include in our plans as large a part of the field of nutrition as we can fence in, our efforts and ingenuity

can with better effect be devoted to such simplification of our problems as will reduce them to single variants.

In a search for more significant observations we are just now taking up a study of Wright's opsonic index as a measure of resistance to disease, of Rountree and Geraghty's phenolsulphonephthalein test of the functional activity of the kidneys, and of catalase determinations on tissues by measuring their capacity to free oxygen from hydrogen peroxide; this last being a function which is prominently affected in characteristic ways by diseased conditions. I believe that it is to be the physiologist, rather than the analyst, who will finally place the cap-sheaf on the shock in this work on the specific effects of foods.

It is comparatively a simple matter to learn how to feed for general results, but the educational and the inspirational value of the process, as well as the highest degree of economic success, is largely lost if we act in ignorance of underlying principles. It is my feeling that those of us who are attempting to learn the *reasons* for things must continue indefinitely, for all we can now see, a general refinement of method all along the line, especially in the choice of observations of scientific significance. The easy work has been done, and future progress will require a more critical attitude toward the whole experimental program, better facilities for the control of conditions affecting results, a sharper distinction between demonstration work and scientific investigation, and, instead of compromising combinations of the two, an intensification of the legitimate characteristics of each.

Notes on European Agricultural Science.*

By W. R. Lazenby,
Ohio State University.

While traveling in England the past summer, I took special pains to observe wherever I could and opportunity permitted, the extent to which the more modern principles of science were applied to practical agriculture. I questioned the more intelligent and more progressive farmers that I had the pleasure of meeting upon such subjects as the use of lime, the importance of bacteria in the soil, the explanation of the loss of soil fertility, and other subjects of a similar character.

I found, as a rule, a good degree of interest in all of these questions. Almost without exception the comment or query was made, "Why cannot our scientific men answer these questions more fully, more clearly, and more definitely." I suppose a general reply to this must be something as follows: The more scientists examine and study the soil in its relation to crops, the more complicated and difficult do they find it to explain the various processes that go on amongst its particles. Until a comparatively recent date it has generally been assumed that when any ordinary soil lost its fertility and the crops thereon grew small what was needed was more plant food and some form of manure was applied accordingly. It was a simple matter for the chemist to determine what the fertilizer should be. If the soil were found to be deficient in some particular element or compound needed by the plant, that particular substance was the one to be supplied. And this assumption from the time of Liebig has developed the great industry of commercial fertilizers, and has given new life to the productiveness of many an apparently sick and exhausted soil.

*This paper, forwarded by Professor Lazenby, who was on a trip around the world, was received too late for presentation at the meeting. —Ed.

During the past thirty years, however, discoveries have been made that give an entirely different aspect to the soil in its relation to the growing crops. It is now known that the soil is the home of many myriads of minute organisms, which in some way contribute very largely to the welfare of our crops. Some of these organisms living upon the roots of the leguminous plants are found to have the power to add nitrogen to the soil. This subject is one of great interest to both the European and the American farmer. The English farmer, especially, is anxious to know why his clover will not grow, for with good clover the other crops in the farm rotation are likely to be good also. Dr. E. J. Russell, of the Rothamsted Experiment Station, is trying to answer this question. I believe it is only about two years ago that Dr. Russell first announced his theory that many soils could have their productive capacity enormously increased if they could be partially sterilized by steam or some other means.

The explanation of the theory, as I understand it, is this. There appears to be at times certain larger and probably more aggressive organisms in the soil that prey upon the smaller and more useful bacteria. When these latter are destroyed certain crops are sure to fail. The action may be likened to that of the white corpuscles of the blood, except that it is just the reversal in the effect; that is, when the larger soil organisms flourish they keep down the useful microbes to such an extent as to prevent them from carrying on their work; or in other words they are harmful, while the white blood corpuscles, by keeping down the injurious forms, are actively helpful. What the farmer needs and wants to know is whether there is any practical way by which these various organisms in the soil can be controlled. I may add that Dr. Russell is still carrying on his experiments at Rothamsted.

Another question that is interesting to the English farmer, and one concerning which we would like to have more light, is whether the new theory as set forth by the United States Department of Agriculture as regards soil fertility can be accepted as practical. This new view is being much discussed and has aroused no little interest in all circles that believe in scientific agriculture. It does not appear to be accepted so far by the European investigators. The English view, at

least, is to attach great importance to the nutrition functions of the soil and of added fertilizers. While some agree that part of the infertility of sour soils may be due to toxic substances, the view that plants excrete these toxic substances is not accepted.

A word as to the use of lime in England. Some fifty years ago lime was used in great quantities, and with apparently good results, but for some years back it has practically been abandoned. The reasons are that the heavy liming began to tell on the fertility of the soil, which threatened to become exhausted, and the decline was further hastened by an increase in cost and the coming in of artificial fertilizers. It is now quite generally believed that the decline in the fertility of certain soils in England is due, in a great part at least, to the gradual exhaustion of lime. The land fails to respond to fertilizers, and a poor growth of grass and the presence of certain weeds and clover sickness are signs of a lack of lime. It is scarcely probable that there will be a return to the old extreme use of lime, but its use in smaller quantities is being very generally discussed.

As an evidence of a greater and growing practical application of science to agriculture in Great Britain, I cite the following subjects upon which papers were read at the last meeting of the British Association for the Advancement of Science, held at Portsmouth: Milk Yield in Cows, British Beet Sugar, Cider Sickness, The Treatment of Wheaten Flour, Smoke Abatement, etc.

NECROLOGY.

During the year the Society lost by death one of its honorary members, Dr. Oskar Kellner, director of the Agricultural Experiment Station at Möckern, Germany; and two of its regular members of long standing—Dr. E. B. Voorhees, director of the New Jersey Experiment Station, and Prof. H. King, of Madison, Wisconsin.

All three of these men held conspicuous positions in the world of agricultural science, and had rendered service of a very high order. The Society is deeply conscious of the loss which agriculture has sustained in their passing from the field of action. It wishes to record briefly some of the salient features of their lives and service in the following sketches, which have been prepared by members upon request.

DR. OSKAR KELLNER.

1851—1911.

Oskar Kellner was born May 13, 1851, at Tillowitz, near Falkenberg, in the Prussian province of Silesia. He died from a stroke of apoplexy at Karlsruhe, September 22, 1911, whence he had gone to preside at the annual meeting of the Association of German Experiment Stations.

Early in his career Kellner directed his attention to animal nutrition, in which field his most notable services were rendered. He was associated for several years with the investigations of Weiske and Emil von Wolff, and following a period of twelve years in Japan as professor of agricultural chemistry in the University of Tokio, was appointed director of the Möckern Experiment Station, in succession to Gustav Kühn. The eighteen years which followed was the period of his life which won for him a position of leadership in the theory of animal nutrition, and made him a worthy successor of such men as Wolff, Henneberg, and Kühn.

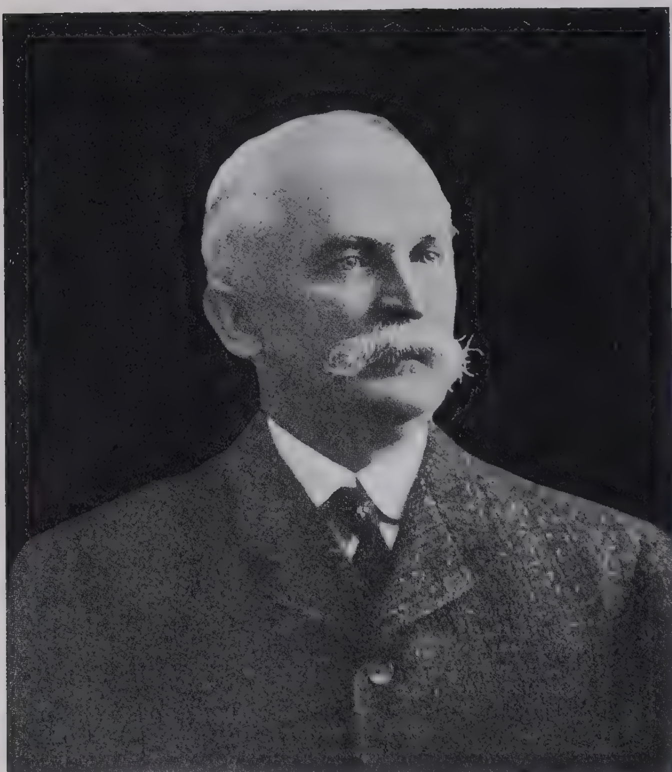
Kellner supplemented the respiration experiments as carried on by Kühn by calorimetric determinations of the energy value of the feeds and the excreta, according to the teachings of Rubner. This study of the metabolism of both matter and energy under varying conditions of feeding led to the discovery that like amounts of digestible nutrients in different feeds have different values, and that the energy required for digestion and the loss due to decomposition, etc., must be taken account of in arriving at the net or available values. Upon this new conception of energy value he worked out his system of "starch values" as a means of comparing feeds and calculating rations.

The results of Kellner's studies were embodied in his well-known treatise on the nutrition of farm animals (*Die Ernährung der landwirtschaftlichen Nutztiere*), published in 1905, which rapidly passed through five editions.

Kellner was not alone an investigator and theorist. He gave freely of his time and strength to the practical interests of agriculture, in experiment and in the protection of the farmers, as well as in the furtherance of their organizations. Since 1905 he had edited *Die landwirtschaftlichen Versuchs-Stationen*, the organ of the German Stations, and since 1902 he had been in editorial management of the *Zentralblatt für Agrikulturchemie*, a standard abstract journal. He had served continuously since 1903 as president of the Association of German Experiment Stations, a service which was to have been crowned on his contemplated retirement with the title of honorary president.

The life which closed at the premature age of sixty years was an extremely active and productive one, had brought both honor and fame, and had placed the name of Kellner high up in the annals of agricultural science.

E. W. ALLEN.



DR. EDWARD BURNETT VOORHEES,
DIRECTOR, NEW JERSEY EXPERIMENT STATIONS.
1856–1911.

DR. EDWARD BURNETT VOORHEES.

1856—1911.

Edward Burnett Voorhees first opened his eyes in this world on the longest day of the year, and he closed them before the years drew nigh when he properly should have said he had no pleasure in them. Twenty years of active, constructive life should have been ahead of him. His fifty-five years were full of good works, far more so than those of many whose lives exceeded his by half as much again, but it was all too short in view of the type of work he was doing and the sort of a man he was.

Dr. Voorhees was born at Minebrook, Somerset County, New Jersey, June 22nd, 1856, the son of John and Sarah (Dilley) Voorhees. His boyhood days were passed on the farm, where he imbibed that practical knowledge of farming operations, that warm sympathy for agricultural pursuits and that love of the out-of-doors which characterized his later life.

Brought up within the folds of the Reformed Church of America (Dutch Reformed), he naturally turned for his collegiate training towards that institution, near at hand, which was affiliated with the denomination. He was graduated from Rutgers College in the class of 1881, receiving the degree of Bachelor of Arts. Three years later, from the same institution, he received the degree of Master of Arts. Having specialized during his undergraduate work in chemistry, and having resolved to make agricultural chemistry his life work, he sought, on graduation, one of the few fountain heads of that day, and associated himself as assistant with the late Dr. W. O. Atwater of Wesleyan University.

The Connecticut Experiment Station at New Haven was then put five years old; that in North Carolina but a few years old; the New Jersey Station was yet in its swaddling clothes, having begun in a modest way only a year before his graduation. After a year's work at Wesleyan, Dr. Voorhees returned in 1882 to begin an uninterrupted service in the New Jersey Station as assistant chemist, chemist, and as director, which lasted for almost thirty years. Save for this single

year in Connecticut, he was as boy, student, investigator, administrator, and teacher, on the red soil of his native State.

Trained under the simple but strong guidance of the late Dr. George H. Cook, for a generation state geologist and for ten years the station's first director, he quickly developed into a leader who won the confidence of every one with whom he came in contact, and whose service to his State, rendered through his study of her needs and his able presentation of the solution of her problems, is beyond compute. To him more than to any other one man of the present generation does New Jersey agriculture owe its present advanced condition.

The enumeration of Dr. Voorhees' society memberships reveals the scope of his activities. Vice-president for ten years, and president for another ten years of the State Board of Agriculture, he was at the forefront of its activities. Secretary and treasurer of the Association of American Agricultural Colleges and Experiment Stations for seven years, and then its president, he was the friend of every land-grant college president and of every station director in the country. He was a member of the American Chemical Society, and as such was the recipient ten years ago of the Nichols Research Gold Medal of that organization, awarded him on account of his able studies of the processes of denitrification, which served to bring him to the notice of chemists in lines other than his own. He joined this organization in 1893, frequently took part in its proceedings, and contributed papers of much value. He held membership in several state organizations, and was active in church circles. His text-books on agronomical subjects have made his name familiar in school and college classrooms. His official writings in bulletins and reports were expressed in clear language, and his many investigations were important contributions to both science and practice.

Some twelve years ago the University of Vermont honored itself in conferring upon Director Voorhees the degree of Doctor of Science. His acknowledgment was a unique one, for he named his son, born, it so happened, on the very day on which the doctorate was conferred upon the father, after Vermont's great statesman, Justin S. Morrill, whose connection with the inception of the land-grant colleges is familiar to every reader of these lines.

Dr. Voorhees' college connections were also important. He was professor of agriculture in Rutgers College for twenty years, and had immediate charge of the college farm for fifteen years. He was greatly interested in the upbuilding of short course work in agriculture. He located its buildings and work on the farm lands, apart from the academic surroundings of the college proper. He so endeared himself to the young men and women who flocked to these short courses, that during the days of his strength they named their agricultural society for him.

Dr. Voorhees was married October 18th, 1883, to Anna E. Amerman, of South Branch, New Jersey, who with a splendid family of boys and girls survives him.

A successful administrator, an accurate investigator, an inspiring teacher, a lovable personality has left us. It is not given to us to know the Great Beyond, but surely somewhere, somehows his mighty spirit and his indomitable energy are still in the Master's service.

> "Green grow the turf above thee,
> Friend of my better days,
> None knew thee but to love thee,
> None named thee but to praise."

J. L. HILLS.

PROF. FRANKLIN HIRAM KING.

1848—1911.

Franklin Hiram King was born on a farm near Whitewater, Walworth County, Wisconsin, June 8, 1848. He died at Madison, Wisconsin, August, 4, 1911. He was graduated from the State Normal School at Whitewater in 1872. It was here, under the inspiring teaching of Prof. T. C. Chamberlin, the distinguished geologist, that he received his first and strongest impulse to scientific study. He became especially interested in the study of the natural sciences during his course in the normal school, and after graduation worked and studied with Professor Chamberlin for a year before joining him in work on the State Geological Survey.

For three years, 1873–1876, he taught science in the high school of Berlin, Wisconsin. During that time he published a scheme for plant analysis which was afterwards incorporated in Wood's botanical textbooks. Following an expedition for the geological survey of the Flambeau River in northern Wisconsin, he spent two years in special study of physics, chemistry, biology, and geology at Cornell University. During this period he completed a careful study (begun during his vacations at the Berlin high school) of the food habits of Wisconsin birds, which was published in a report of the State Geological Survey under the title of "Economic Relations of Wisconsin Birds."

For ten years, 1878–1888, Professor King taught science in the State Normal School at River Falls, Wisconsin, one summer during this period being spent at the Johns Hopkins Seaside Laboratory, then at Beaufort, North Carolina, and another with the U. S. Geological Survey in the study of terminal moraines in North Dakota. It was during this period that he undertook, with the aid of his wife, the preparation of relief models and maps for use in instruction in physiography and meteorology, devising a mechanical method for rapid and exact reproduction of such maps and models, many of which were prepared for various educational institutions in this country.

PROF. FRANKLIN HIRAM KING,

A Pioneer in Physics as Applied to Agriculture.

1848–1911.

Professor King's broader career as an agricultural educator and investigator may be said to date from 1888, when he accepted the chair of agricultural physics in the University of Wisconsin, the first of its kind to be established in this country. Here he opened up the important but neglected field of physics as applied to agriculture, and laid the foundations of a science of rural engineering. In this field his contributions have been as varied as they are valuable. He has reported work of a fundamental character on the movement and conservation of soil water, the soluble salts of the soil in relation to soil fertility and the conditions which control their production and loss, the water requirements of crops, protection of sandy soils from wind erosion, irrigation and drainage, windmills as motors, the construction of silos and the preparation of silage, the construction and ventilation of farm buildings, besides many other subjects which might be enumerated. Much of this work is embodied in permanent form in his books on "The Soil" (1895); "Irrigation and Drainage" (1899); "Physics of Agriculture" (1901); "Ventilation for Dwellings, Rural Schools, and Stables" (1908), and also in bulletins of the Wisconsin Experiment Station, publications of the U. S. Department of Agriculture and the U. S. Geological Survey, encyclopedia articles, and periodical literature.

In 1901 Professor King was appointed chief of the Division of Soil Management of the Bureau of Soils, U. S. Department of Agriculture. In this position, which he held about three years, he devoted himself mainly to a study of crop yields and soil composition in relation to soil productivity, the results appearing in part in a bulletin (No. 26) of the Bureau of Soils.

After his retirement from this position he returned to his home in Madison, Wisconsin, and devoted himself largely to writing, with occasional trips to different parts of this country and abroad to study special agricultural problems and conditions. One especially noteworthy outcome of the latter phase of his activity is his book, "Farmers of Forty Centuries" (1911), which came from the press after his death. This book gives with a thoroughness, fidelity, and openmindedness rarely equalled, the results of observations made during a trip through China, Korea, and Japan, on the peculiarly efficient oriental methods of maintaining soil fertility.

Professor King was a tireless and productive worker and writer. His work is characterized by a thoroughness and finality which inspires confidence in its scientific reliability. In his tireless, patient, openminded pursuit of truth and uncompromising fidelity to it when discovered, he evinced in high degree the qualities of the true scientist. A colleague says—"In the accumulation of facts and detailed data from long-continued and carefully conducted investigations, Professor King's work was remarkable. In his mastery of details he had few equals. The thoroughness of his investigation was such that when he completed a piece of work it was finished; and his loyalty to scientific truth absolute . . . But above and beyond all his work, we value most the spirit of the worker . . . . The discovery of truth is the joy of the scientist, and whether the discovery were made by himself or by another, the satisfaction seemed equally great to this man."

Professor King was especially ingenious in devising methods and apparatus for teaching and experimental purposes. He was not only a master builder but he fashioned efficient tools for the work. He possessed a rare combination of powers of keen and accurate observation, clear scientific analysis and interpretation, and understanding of the practical application of scientific truth to agricultural problems, as well as ability to present his ideas clearly. Hence, while he wrote much, he wrote well, leaving to us a rich heritage of scientific and practical knowledge in enduring form.

The University of Wisconsin conferred on Professor King the honorary degree of Doctor of Science in 1910.

No account, however brief, of the life and services of Professor King should fail to note the debt he owed, and always so gratefully acknowledged, to his devoted and accomplished wife for her active and intelligent assistance in much of his work.

W. H. BEAL.

LIST OF OFFICERS AND MEMBERS

OF THE

Society for the

Promotion of Agricultural Science

1912

OFFICERS FOR THE SOCIETY FOR 1912.

President—Eugene Davenport, *Urbana, Illinois.*

Secretary-Treasurer—E. W. Allen, Department of Agriculture, *Washington, D. C.*

Custodian—W. J. Beal, *Amherst, Mass.*

Assistant Custodian—W. D. Hurd, *Amherst, Mass.*

Executive Committee	W. H. Jordan, *Geneva, New York.* H. P. Armsby, *State College, Pennsylvania.* H. L. Russell, *Madison, Wisconsin.*

Past Presidents.

Term began		*Expired*
1880	W. J. Beal, *of Michigan*	1882
1881	W. H. Brewer, *of Connecticut*	1884
1884	H. E. Alvord, *of New York*	1886
1886	E. L. Sturtevant, *of New York*	1887
1887	R. C. Kedzie, *of Michigan*	1889
1889	C. E. Bessey, *of Nebraska*	1891
1891	I. P. Roberts, *of New York*	1893
1893	W. Saunders, *of Ontario, Canada*	1895
1895	W. R. Lazenby, *of Ohio*	1897
1897	B. D. Halsted, *of New Jersey*	1899
1899	W. J. Beal, *of Michigan*	1901
1901	W. H. Jordan, *of New York*	1903
1903	William Frear, *of Pennsylvania*	1905
1905	H. P. Armsby, *of Pennsylvania*	1907
1907	T. F. Hunt, *of Pennsylvania*	1909
1909	S. M. Tracy, *of Mississippi*	1911

Past Secretaries.

1880	E. L. STURTEVANT, *of Massachusetts* . . .	1882
1882	G. C. CALDWELL, *of New York*	1883
1883	F. A. GULLEY, *of Mississippi*	1885
1885	B. D. HALSTED, *of Iowa*	1886
1886	W. R. LAZENBY, *of Ohio*.	1891
1891	L. O. HOWARD, *of District of Columbia* . .	1893
1893	W. FREAR, *of Pennsylvania*	1895
1895	C. S. PLUMB, *of Indiana*	1899
1899	T. F. HUNT, *of Ohio*	1900
1900	F. M. WEBSTER, *of Illinois*	1905
1905	F. W. RANE, *of Massachusetts*	1910
1910	E. W. ALLEN, *of District of Columbia* . . .	

MEMBERSHIP OF THE SOCIETY.

Honorary Member.

1899. HON. JAMES WILSON, LL. D.; Secretary of Agriculture, *Washington, D. C.*

Regular Members.

[Arranged Alphabetically.]

The Prefixed Date is the Year of Election.

1907. EDWIN WEST ALLEN, B. S. (Mass. Agr. Coll. and Boston Univ., '85), Ph. D. (Göttigen, '90); *U. S. Dept. Agr., Washington, D. C.;* Asst. Chem. Mass. Expt. Sta., '85–'88; Asst. Office Expt. Stas., '90–'93; Asst. Dir., do., '93—; Ed. Expt. Sta. Record, '95—.

1889. HENRY PRENTISS ARMSBY, B. S. (Worcester Poly. Inst., '71), Ph. B. (Sheffield Sci. School, '74), Ph. D. (Yale Univ., '79), LL. D. (Univ. Wis., '04); *State College, Pa.;* Chem. Conn. Expt. Sta., '77–'81; Vice Prin. Storrs Agr. School, '81–'83; Prof. Agr. Chem., Univ. Wis., '83–'87; Dir. Pa. Expt. Sta., '87–'07; Dean School of Agr., Penn. State College, '95–'02; Dir. Inst. Animal Nutrition, '07—.

1886. JOSEPH CHARLES ARTHUR, B. S. (Iowa State Coll., '72), M. S. (do., '77), D. Sc. (Cornell Univ., '86); *Lafayette, Ind.;* Instr. Biol., Iowa State Coll., '76–78; Instr. Bot., Univ. Wis., '79–'81; do., Univ. Minn., '82; Bot. N. Y. Expt. Sta., '84–'87; Prof. Bot., Purdue Univ., '87–88; Prof. Veg. Phys. and Path., do., and Bot., Ind. Expt. Sta., '88—.

1906. LIBERTY HYDE BAILEY, B. S. (Mich. Agr. Coll., '82), M. S. (do., '85), LL. D. (Univ. Wis., '07); *Ithaca, N. Y.;* Prof. Hort. and Landscape Gardening, Mich. Agr. Coll., '84–'88; Prof. Hort., Cornell Univ., '88–'03; Dir. Coll. Agr. and Expt. Sta., Cornell Univ., '03—.

1909. WALTER HENRY BEAL, A. B. and M. E. (Va. Poly. Inst., '86); *Washington, D. C.;* Asst. Chem., Mass. Expt. Sta., '87–'91; Asst. Office of Expt. Stas., U. S. Dept. Agr., '91—; Chief of Editorial Division, '02—.

1879. WILLIAM JAMES BEAL, A. B. (Univ. Mich., '59), A. M. (do., '63), Sc. B. (Harvard Univ., '65), Sc. M. (Univ. Chicago, '75), Ph. D. (Univ. Mich., '80), D. Sc. (Mich. Agr. Coll., '05); *Amherst, Mass.;* Prof. Bot., Mich. Agr. Coll., '70–'72; Prof. Bot. and Hort., '72–'81; Prof. Bot. and Forestry, '81–'03; Prof. Bot., '03–'10; Prof. Emeritus, '10—.

1880. CHARLES EDWIN BESSEY, B. Sc. (Mich. Agr. Coll., '69), M. Sc. (Mich. Agr. Coll., '72), Ph. D. (State Univ. Iowa, '79), LL. D. (Iowa Agr. Coll., '98); *Lincoln, Nebr.;* Prof. Bot., Iowa Agr. Coll., '70–'84; Prof. Bot., Univ. Nebr., '84—; Acting Pres. Iowa Agr. Coll., '82; Acting Chancellor Univ. Nebr., '88–'91, and '99–'00; Dean Industrial Coll., Univ. Nebr., '84–'88, and '95—; Dean Coll. of Literature, Science and Arts, '88–'91; Dir. Nebr. Expt. Sta., '87–'89; Head Dean of Univ., '09—.

1893. HENRY LUKE BOLLEY, B. S. (Purdue Univ., '88), M. S. (do., '89); *Agricultural College, N. Dak.;* Instr. Biol. and Asst. Bot. to Expt. Sta., Purdue Univ., '90; Prof. Bot. and Plant Path., N. Dak. Agr. Coll. and Bot. and Plant Path. of Expt. Sta. do., '90—.

1909. WILLIAM PENN BROOKS, B. Sc. (Mass. Agr. Coll., '75), Ph. D. (Halle, '97); *Amherst, Mass.;* Prof. Agr., Imp. Coll. Agr., Sapporo, Japan, '77–'88; Prof. Bot., do., '81–'88; Pres., do., *ad interim* '80–'83, and '86–'87; Prof. Agr. and Agr., Mass. Agr. Coll. and Expt. Sta., '89–09; acting Pres. and Dir., do., '05, '06; Dir. Expt. Sta., '06—.

1905. BURT C. BUFFUM, B. S. (Col. Agr. Coll., '90), M. S. (do., '93); *Worland, Wyo.;* Asst. Met. and Irr. Eng., Col. Agr. Coll., '90–'91; Prof. Hort. and Met., Univ. Wyo. and Bot. Wyo. Expt. Sta., '91–'92; Prof. Agr. and Hort., do., '91–'00; Vice Dir. do. Expt. Sta., '96–'00; Prof. Agr., Col. Agr. Coll., '00–'02;

Dir. Wyo. Expt. Sta., and Prof. Agr. and Hort., Univ. Wyo., '02–'07; Plant Breeder and Mgr. Wyo. Seed Breeding Co., '07—.

1901. EDGAR ALLEN BURNETT, B. S. (Mich. Agr. Coll., '87); *Lincoln, Nebr.;* Asst. Mich. Agr. Coll., '89–'93; Prof. An. Husb., S. Dak. Agr. Coll., '96–'99; Prof. An. Husb., Univ. Nebr., '99—; Dir. Nebr. Expt. Sta., '01—; Dean Coll. Agr. '09—.

1908. KENYON L. BUTTERFIELD, B. S. (Mich. Agr. Coll., '91), A. M. (Univ. Mich., '02); *Amherst, Mass.;* Supt. Mich. Farmers' Institutes; Instr. Univ. Mich., '02; Pres. Rhode Island Coll., '03–'06; Pres. Mass. Agr. Coll. and Prof. Rural Sociol., '06—.

1909. FRANK KENNETH CAMERON, A. B. (Johns Hopkins, '91), Ph. D. (do., '94); *Washington, D. C.;* Fellow Cornell, '94–'95; Assoc. Prof. Catholic Univ., '95–'97; Asst. Physical Chem., Cornell, '97–'98; Expert U. S. Dept. Agr., '98–'99; Soil Chemist, do., '99—.

1908. MARK ALFRED CARLETON, B. S. (Kans. Agr. Coll., '87), M. S. (do., '93); *Washington, D. C.;* Asst. Bot. Kans. Expt. Sta., '92–'93; Cerealist, Bur. Plant Indus., U. S. Dept. Agr., '94—.

1905. LOUIS GEORGE CARPENTER, B. S. (Mich. Agr. Coll., '79), M. S. (do., '84), LL. D. (do., '07); *Fort Collins, Col.;* Asst. Prof. Mich. Agr. Coll., '85–'88; Irr. Eng., Col. Agr. Coll. and Expt. Sta., '88–'10; Dir. Expt. Sta. do., '99–'10; State Eng., '03–'05; private work, '10—.

1901. LOUIS ADELBERT CLINTON, B. S. (Mich Agr. Coll., '89), M. S. (do., '97); *Storrs, Conn.;* Asst. to Dir. Mich. Expt. Sta., '89–'93; Asst. Prof. Agr., Clemson Coll., '93–'95; Asst. Agr. Cornell Expt. Sta., '95–'02; Dir. Storrs Expt. Sta. and Prof. Agr., Conn. Agr. Coll., '02—.

1910. JOHN WALDO CONNAWAY, D. V. S. (Chicago Vet. Coll., '90), M. D. (Univ. Mo., '91); *Columbia, Mo.;* Prof. Physiology, Univ. Mo., '91–'97; Vet. Expt. Sta., do., '97–'00; Prof. Compar. Med., and Vet. to Expt. Sta., Univ. Mo., '00—.

1910. LEE CLEVELAND CORBETT, B. S. (Cornell Univ., '90), M. S. (do., '96); *Washington, D. C.;* Asst. Hort. Cornell Univ., '91–'93; Prof. Hort. and Forestry, S. Dak. Coll., '93–'95; do., Univ. W. Va. and Expt. Sta., '95–'01; Hort. U. S. Dept. Agr., '01—.

1902. CHARLES FRANCIS CURTISS, B. S. A. (Iowa State Coll., '87), M. S. A. (do., '93), D. Sc. (Mich. Agr. Coll., '07); *Ames, Ia.;* Asst. Dir. Iowa Expt. Sta., '91–'97; Prof. Agr. and Acting Dir. Iowa Expt. Sta., '97–'00; Prof. Agr. and Dir., do., '00–'02; Dean and Dir., '02—.

1911. WILLIAM HADDOCK DALRYMPLE, M. R. C. V. S. England, '86; *Baton Rouge, La.;* Prof. Vet. Sci., La. State Univ., '89—; Vet., La. Expt. Sta., '89—.

1906. EUGENE DAVENPORT, B. S. (Mich. Agr. Coll., '78), M. S. (do., '81), M. Agr. (do., '95), LL. D. (do., '07); *Urbana, Ill.;* Prof. Agr., Mich. Agr. Coll., '89–90; Dir. Coll. of Agr., Piracicaba, Brazil, '91–'92; Dean Coll. of Agr., Univ. Ill., '95—; Dir. Agr. Expt. Sta., '96—.

1911. WILLIAM RUFUS DODSON, B. S. (Univ. Mo., '90), A. B. (Harvard Univ., '94); *Baton Rouge, La.;* Asst. Biol., Univ. Mo., '90–'93; Prof. Bot., La. Univ., '94–'02; Asst. Dir., La. Expt. Stas., '02–05; Dir., do., '05—; Dean, Coll. Agr., La. Univ., '09—.

1897. BENJAMIN MINGE DUGGAR, B. S. (Miss. Agr. Coll., '91), M. S. (Ala. Poly. Inst., '92), A. B. (Harvard Univ., '94), A. M. (do., '95), Ph. D. (Cornell Univ., '98); *Ithaca, N. Y.;* Asst. Ill. State Lab. Nat. Hist., '95–'96; Instr. Bot., Cornell Univ. and Asst. Cryptg. Bot., Expt. Sta., '96–'99; Asst. Prof. Bot., Cornell, '00–'01; Physiologist U. S. Dept. Agr., '01–'02; Prof. Bot., Univ. Mo., '02–'07; Plant Physiologist, Coll. Agr. and Expt. Sta., Cornell Univ., '07—.

1910. JOHN FREDERICK DUGGAR, B. S. (Miss. Agr. Coll., '87), M. S. (do., '88); *Auburn, Ala.*; Asst. in Agr., Tex. Agr. Coll., '87–'89; Asst. Dir. S. C. Expt. Sta., '90–'92; Agr. Editor Office Expt. Stas., U. S. Dept. Agr., '93–'95; Prof. Agr., Ala. Poly. Inst., '96—; Dir. Ala. Expt. Sta., '03—.

1903. Rollins Adams Emerson, B. S. (Univ. Nebr., '97); *Lincoln, Nebr.;* Hort. Editor Office Expt. Stas., U. S. Dept. Agr., '97–'98; Asst. Prof. Hort., Univ. Nebr., '99–'04; Prof. Hort., do., '05—; Hort. Expt. Sta., '98—.

1899. David Grandison Fairchild, B. S. (Kans. State Coll., '88), M. S. (do., '93); *Washington, D. C.;* Naples Zool. Sta., '93; Breslau and Berlin, '94; Bonn, '95; Buitenzorg Botanic Gardens, '96; Asst. Path. U. S. Dept. Agr., '89–'92; Special Agt. in charge Sect. Seed and Plant Introduction, '97–'98; Agr. Explorer, '98–'03; in charge Foreign Seed and Plant Introduction, U. S. Dept. Agr., '03—.

1880. William Gibson Farlow, A. B. (Harvard Univ., '66), M. D. (do., '70), LL. D. (do., '96; Univ. Glasgow, '01; Univ. Wis., '04); *24 Quincy St., Cambridge, Mass.;* Asst. Prof. Bot., Harvard Univ., '74–'79; Prof. Cryptg. Bot., do., '79—.

1909. Edward Holyoke Farrington, B. S. (Univ. Me., '81), M. S. (Yale, '82); *Madison, Wis.;* Chem. Ill. Expt. Sta., '90–'94; Dairy School, Univ. Wis., '94–'04; Prof. Dairy Husb., Univ. Wis., '94—.

1901. Ephriam Porter Felt, B. Sc. (Mass. Agr. Coll., '91), D. Sc. (Cornell Univ., '94); *Albany, N. Y.;* Teacher Nat. Sci., Clinton Liberal Inst., '93–'95; Asst. State Ento. of N. Y., '95–'98; State Ento. of N. Y., '98—.

1890. Bernhard Edward Fernow (Münden Forest Acad. grad., '73), LL. D. (Univ. Wis., '97; Queen's, '03); *Toronto, Can.;* Chief, Div. Forestry, U. S. Dept. Agr., '86–'98; Dir. N. Y. State Coll. of Forestry, '98–'03; Lecturer Yale Forestry School, '04; Prof. of Forestry, Univ. of Toronto, '07—.

1911. Martin Luther Fisher, B. S. (Purdue Univ., '03), M. S. (Univ. Wis., '11); *Lafayette, Ind.;* Asst. in Agr., Purdue Univ., '03–'04; Instr. Agr., do., '04–'06; Asst. Prof. Agron., do., '06–'08; Assoc. Prof. Agron., do., '08–'10; Prof. Crop Prod., do., '10—; Asst. Agr., Indiana Expt. Sta., '03–'10; Assoc. in Crops, do., '10—.

1910. Ernest Browning Forbes, B. Sc. (Univ. Ill., '97), B. S. Agr. (do., '02), Ph. D. (Univ. Mo., '08); *Wooster, Ohio;* Zool. Asst., Ill. Biol. Sta., '94–'96; Asst. to State Ento. of Minn., '97–'98; Acting State Ento. Minn., '01; Asst. in An. Husb., Ill. Expt. Sta., '01–'02; Instr. An. Husb., Univ. Ill., '02–'03; Asst. Prof. An. Husb., Univ. Mo., '03–'07; Chief in Nutrition, Ohio Expt. Sta., '07—.

1908. Stephen Alfred Forbes, Ph. D. (Ind. Univ., '84), LL. D. (Univ. Ill., '05); *Urbana, Ill.;* Prof. Zool., Univ. Ill., '84–'09; State Ento. Ill., '82—; Dir. Ill., State Lab. of Nat. Hist., 77—; Dean Coll. of Sci., Univ. of Ill., '88—.

1911. George Stronach Fraps, B. S. (N. C. Agr. Coll., '96), Ph. D. (Johns Hopkins Univ., '99); *College Station, Tex.;* Asst. Prof. Chem., N. C. Agr. Coll., and Asst. Chem. in Expt. Sta., '99–'03; Asst. Chem. Tex. Expt. Sta., '03–'04; Assoc. Chem., do., '04–'05, Chem., do., '05—; Assoc. Prof. Chem., Tex. Agr. Coll., '03–'05; Acting Prof., do., '05–'06; Assoc. Prof. Agr. Chem., do., '06—; State Chem., '06—.

1888. William Frear, A. B. (Bucknell Univ., '81), Ph. D. (Ill. Wesleyan Univ., '83); *State College, Pa.;* Asst. Sci., Bucknell Univ., '81–'83; Asst. Chem. U. S. Dept. Agr., '83–'85; Prof. Agr. Chem., Pa. State Coll., '85—; vice Dir. and Chem. Pa. Expt. Sta., '87—.

1908. Beverly Thomas Galloway, B. S. (Univ. Mo., '94), LL. D. (do., '02); *Washington, D. C.;* Asst. Hort., Univ. Mo., '84–'87; Asst. Path., U. S. Dept. Agr., '87–'88; Path. and Chief, Div. Veg. Path. and Physol., do., '88–'01; Chief Bur. Plant Indus., do., '01—.

1894. Harrison Garman, *Lexington, Ky.;* Asst. State Lab. Nat. Hist. Ill., '83–'89; Asst. Prof. Zool., Univ. Ill., '85–'89; Ento. and Bot. Ky. Expt. Sta., '89—; State Ento., Ky. '97—.

1894. Charles Christian Georgeson, B. S. (Mich. Agr. Coll., '78), M. S. (do., '82); *Sitka, Alaska;* Asst. Ed. of *Rural New Yorker*, '78–'80; Prof. Agr. and

Hort., Tex. A. and M. Coll., '80–'83; Prof. Agr. Coll. of Agr., Imperial Univ., Tokyo, Japan, '86–'89; Prof. Agr. Kans. State Agr. Coll., '90–'97; Special Agt. U. S. Dept. Agr., Dairy Industry, Denmark, '93; Asst. Agrostologist U. S. Dept. Agr., '97–'98; Special Agt. in charge Alaska Expt. Sta., do., '98—.

1893. Clarence Preston Gillette. B. S. (Mich. Agr. Coll., '84), M. S. (do., '88); *Fort Collins, Col.;* Asst. Zool. Mich. Agr. Coll., '87–'88; Ento. Iowa Expt. Sta., '88–'91; Prof. Zool. and Ento., Col. Agr. Coll. and Ento. Expt. Sta., do., '91—; Dir. Expt. Sta., do., '10—.

1911. Arthur Goss, B. S. (Purdue Univ., '88), M. S. (do., '95); *Lafayette, Ind.;* Asst. Chem., Ind. Expt. Sta., '88–'92; Asst., Ind. Weather Serv., '89–'92; Prof. Chem., N. Mex. Agr. Coll., and Chem. in Expt. Sta., '92–'03; Vice-Dir., N. Mex. Expt. Sta., '95–'00; Dir., Ind. Expt. Sta., '03—.

1909. Harry Sands Grindley, B. S. (Univ. Ill., '88), Sc. D. (Harvard, '94); *Urbana, Ill.;* Asst. Chem. Univ. Ill., '88–'92; Asst. Chem. Harvard, '92–'93; Fellow Harvard, '93–'94; Instr. Chem., Univ. Ill., '94–'95; Asst. Prof. Chem., do., '95–'99; Assoc. Prof. Chem., do., '99–'04; Prof. and Dir. Chem. Lab., do., '04–'07; Prof. An. Chem., do., and Chief An. Chem., Expt. Sta., '07—.

1909. Theophilus L. Haecker, *University Farm, St. Paul, Minn.;* in charge Dairy Husb., Minn. Univ. and Expt. Sta., '92–'07; Prof. Dairy Husb. and An. Nutrition, do., '07–'09; Prof. Dairying, An. Husb. and An. Nutrition, do., '10—.

1880. Byron David Halsted, B. S. (Mich. Agr. Coll., '71), M. S. (do., '74), Sc. D. (Harvard Univ., '78); *New Brunswick, N. J.;* Ed. *American Agriculturist*, '79–'85; Prof. Bot., Iowa State Coll., '85–'89; Prof. Bot. and Hort., Rutgers Coll., '89–'10; Bot. N. J. Expt. Sta., '89—.

1902. Niels Ebbensen Hansen, B. S. (Iowa State Coll., '87), M. S. (do., '95); *Brookings, S. Dak.;* Asst.

Prof. Hort., Iowa State Coll., '91–'95; Prof. Hort. and Forestry, S. Dak. Agr. Coll., and Hort. Expt. Sta., '95—.

1910. Joseph Nelson Harper, B. S. (Miss. Agr. Coll., '95), M. A. (Ky. Agr. Coll., '06); *Clemson College, S. C.;* Dairy Husb., Miss. Expt. Sta., '95; Dairy Husb., Ky. Expt. Sta., '96–'98; Agriculturist, do., '98–'05; Dir. and Agron. S. C. Expt. Sta., '06—.

1911. Edwin Bret Hart, B. S. (Univ. Mich., '97); *Madison, Wis.;* Asst. Chem., N. Y. Expt. Sta., '97–'00; Assoc. Chem., do., '06; Prof. Agr. Chem., Univ. Wis., and Chem. Wis. Expt. Sta., '06—.

1910. Burt Laws Hartwell, B. S. (Mass. Agr. Coll. and Boston Univ., '89), M. S. (Mass. Agr. Coll., '00), Ph. D. (Univ. Pa., '03); *Kingston, R. I.;* Asst. Chem. Mass. Expt. Sta., '89–'91; Asst. Chem. R. I. Expt. Sta., '91–'03; Assoc. Chem., do., '03–'07; Chem., do., '07—; Prof. Agr. Chem., R. I. State Coll., '08—.

1905. Willet Martin Hays, B. Agr. (Iowa State Coll., '85), M. Agr. (do., '86); *Washington, D. C.;* Asst. Iowa Agr. Coll., '86; Assoc. Ed., *Prairie Farmer*, '87, Asst. in Agr., Iowa Agr. Coll., '88–'89; Prof. Agr. and Agriculturist Minn. Agr. Coll. and Expt. Sta., '90–'91; Prof. Agr. and Agriculturist N. Dak. Agr. Coll. and Expt. Sta., '92–'93; Prof. Agr. and Agriculturist Minn. Agr. Coll. and Expt. Sta., '93–'04; Asst. Sec. of Agr., U. S. Dept. Agr., '04—.

1911. Harry Hayward, B. S. (Cornell Univ., '94), M. S. (do., '01); *Newark, Del.;* Asst. Prof. Dairy Husb., Pa. State Coll., '97–'02; Assoc. Prof. An. and Dairy Husb., N. H. Agr. Coll., '02–'03; Asst. Chief Dairy Div., U. S. Dept. Agr., '03; Dir. Agr. Dept., Mount Hermon School, '03–'06; Dean Agr. Dept. Del. Coll., and Dir. Del. Expt. Sta., '06—.

1909. William Parker Headden, A. B. (Dickinson, '72), A. M. (do., '75), Ph. D. (Univ. Giessen, '74); *Fort Collins, Col.;* Asst., Univ. Pa., '74–'76; Prof. Chem., Md. Agr. Coll., '80–'84; do., Univ. Denver, '84–'89; do., S. Dak. School of Mines, '89–'91; Dean,

do., '92–'93; Prof. Chem. and Geol., Col. Agr. Coll., and Chem., Expt. Sta., '93—.

1909. ULYSSES PRENTISS HEDRICK, B. S. (Mich. Agr. Coll., '93), M. S. (do., '95); *Geneva, N. Y.;* Asst. Hort., Mich. Agr. Coll., '93–'95; Prof. Bot. and Hort., Ore. Agr. Coll., and Hort. Expt. Sta., '95–'97; Prof. Bot. and Hort., and Hort. Expt. Sta., Utah, '97–'99; Prof. Hort., Mich. Agr. Coll., '99–'05; Hort., N. Y. Expt. Sta., '05—.

1880. EUGENE WALDEMAR HILGARD, Ph. D. (Heidelberg, '53), LL. D. (Columbia Univ., '87); *Berkeley, Cal.;* State Geol., Miss., '58–'72; Prof. Chem., Univ. Miss., '66–'73; Prof. Geol. and Nat. Hist., Univ. Mich., '73–'75; Prof. Agr., Univ. Cal., and Agriculturist, Expt. Sta., '75–'06; Dir. Cal. Expt. Sta., '88–'06; Prof. Emeritus, '06—.

1905. JOSEPH LAWRENCE HILLS. B. Sc. (Mass. Agr. Coll. and Boston Univ., '81), D. Sc. (honorary, '03, Rutgers Coll.); *Burlington, Vt.;* Asst. Chem., Mass. Expt. Sta., '82–'83; Asst. Chem., N. J. Expt. Sta., '84–'85; Chem. Phos. Mining Co., Ltd., Beaufort, S. C., '85–'88; Chem., Vt. Expt. Sta., '88–'98; Dir., do., '98—; Prof. Agr. Chem., Univ. Vt., '93—; Dean, Dept. Agr., do., '98—.

1911. CYRIL GEORGE HOPKINS, B. S. (S. Dak. Agr. Coll., '90), M. S. (Cornell Univ., '94), Ph. D. (do., '98); *Urbana, Ill.;* Asst. Chem., S. Dak. Agr. Coll. and Expt. Sta., '90–'92; do., Cornell Univ., '92–'93; Acting Prof. Pharm., S. Dak. Agr. Coll., '93–'94; Chem., Ill. Expt. Sta., '94—; Prof. Agron., Univ. Ill., '00—.

1889. LELAND OSSIAN HOWARD, B. S. (Cornell Univ., '77), M. S. (do., '86), Ph. D. (Georgetown Univ., '96); *Washington, D. C.;* Asst. Ento., U. S. Dept. Agr., '78–'94; Chief Ento., do., '94—; Perm. Sec., A. A. A. S., '98—.

1903. THOMAS FORSYTH HUNT, B. S. (Univ. Ill., '84), M. S. (do., '92), D. Agr. (do., '04), D. Sc. (Mich. Agr. Coll., '07); *State College, Pa.;* Asst. State Ento. of

Ill., '85–'86; Asst. Agr., Univ. Ill., '86–'88; Asst. Agr., Ill. Expt. Sta., '88–'91; Prof. Agr., Pa. State Coll., '91–'92; Prof. Agr., Ohio State Univ., '92–'95; Dean, Coll. Agr., Ohio State Univ., '95–'03; Prof. Agron., Cornell Univ., and Agron., Expt. Sta., '03–'06; Dean Coll. Agr., and Dir. Agr. Expt. Sta., Pa. State Coll., '06—.

1908. WILLIAM DANIEL HURD, B. S. (Mich. Agr. Coll., '99), M. Agr. (do., '08); *Amherst, Mass.;* Instr., Lansing High School, '99–'01; Prof. Hort., Briarcliff Agr. School, '01–'03; Prof. Agr., Univ. Me., '03–'05; Acting Dean Coll. of Agr., do., '05–'06; Dean '06–'09; Dir. of Short Courses, Mass. Agr. Coll., '09—.

1898. HENRY CLAY IRISH, B. S. (S. Dak. Agr. Coll., '91), M. S. (Iowa State Coll., '98); *Missouri Botanical Garden, St. Louis, Mo.;* Hort. Asst., Mo. Bot. Gard., '95–'02; Supt., do., '03—.

1908. MYER EDWARD JAFFA, Ph. B. (Univ. Cal., '77), M. S. (do., '96); *Berekley, Cal.;* Asst. Chem. U. S. Census, '79–'80; Asst. Agr. Dept., Univ. Cal., '80–'81; Asst. Chem. Northern Transcontinental Surv., '81–'83; Asst., Univ. Cal., '83–'96; Asst. Prof. Agr. in charge Agr. Chem., do., 96—.

1885. EDWARD HOPKINS JENKINS, A. B. (Yale Univ., '72), Ph. D. (do., '79); *New Haven, Conn.;* Chem., Conn. Expt. Sta., '76—; Vice Dir., do., '82–'00; Dir., do., '00—; Treas., do., '01—.

1894. WHITMAN HOWARD JORDAN, B. S. (Univ. Me., '75), M. S. (do., '79), D. Sc. (do., '96), LL. D. (Mich. Agr. Coll., '07); *Geneva, N. Y.;* Asst. Chem., Conn. Expt. Sta., '78–'79; Instr. Agr., Univ. Me., '79–'80; Prof. Agr. and Agr. Chem., Pa. State Coll., '81–'85; Dir. Me. Expt. Sta., '85–'96; Prof. Agr., Univ. Me., '94–'96; Dir. N. Y. Expt. Sta., '96—.

1909. BENJAMIN WESLEY KILGORE, B. S. (Miss. Agr. Coll., '88), M. S. (do., '90): *Raleigh, N. C.;* Asst. Chem., Miss. Agr. Coll., '88–'89; do., N. C. Expt. Sta., '89–'97; Prof. Chem., Miss. Agr. Coll. and Agr. Expt. Sta., '97–'99; Dir. N. C. Expt. Sta., '01–'07; Dir. N. C. State Expt. Sta., '07—; State Chem. N. C., '99—.

1911. HENRY GRANGER KNIGHT, A. B. (Univ. Wash., Seattle, '02), A. M. (do., '04); *Laramie, Wyo.;* Asst. Chem. Univ. Wash., '00–'01; Instr., do., '01–'02; Asst. Chem., Univ. Chicago, '02–'03; Asst. Prof. Chem., Univ. Wash., '03–'04; Prof. Chem., Univ. Wyo., and State Chem., '04——; Dir., Wyo. Expt. Sta., '10—.

1889. EDWIN FREMONT LADD, B. Sc. (Univ. Me., '84); *Agricultural College, N. Dak.;* Asst. Chem. N. Y. State Expt. Sta., '84–'87; Chief Chem., do., '87–'90; Prof. Chem., N. Dak. Agr. Coll., and Chem. Expt. Sta., '90—; Food Comr. and State Chem., N. Dak., '00—.

1883. WILLIAM RANE LAZENBY, B. Agr. (Cornell Univ., '74), M. Agr. (Iowa Agr. Coll., '87); *Columbus, Ohio;* Instr. Hort., Cornell Univ., '74–'77; Asst. Prof. Hort., do., '77–'81; Prof. Hort. and Bot., Ohio State Univ., '81–'82; Dir. Ohio Expt. Sta., '82–'87; Prof. Hort. and Forestry, Ohio State Univ., '82–'09; Prof. Forestry, do., '09—.

1899. JOSEPH BRIDGEO LINDSEY, B. Sc. (Mass. Agr. Coll., '83), Ph. D. (Univ. Göttingen, '92); *Amherst, Mass.;* Asst. Chem., Mass. State Expt. Sta., '83–'85; Commercial Chem., '85–'89; Assoc. Chem., Mass. State Expt. Sta., '92–'95; Head Dept. Foods and Feeding, Hatch Expt. Sta., '95–'07; Chem., Mass. Expt. Sta., '07—; Vice Dir., do., '09—; Head Dept. Chem., Mass. Agr. Coll. and Goessmann Prof. of Agr. Chem., '11—.

1911. FREDERICK BLOOMFIELD LINFIELD, B. S. A. (Ontario Agr. Coll., '91); *Bozeman, Mont.;* Asst. in Dairying, Ontario Agr. Coll., '92–'93; Prof. Anim. Indus. and Dairying, Utah Agr. Coll., '93–'02; Prof. Agr., Mont. Agr. Coll., '02—; Acting Dir., Mont. Expt. Sta., '03; Dir., do., '04—.

1909. JACOB G. LIPMAN, B. Sc. (Rutgers, '98), A. M. (Cornell, '00), Ph. D. (do., '03); *New Brunswick, N. J.;* Asst. Chem., N. J. Expt. Sta., '98–'99; Fellow Chem., Cornell, '01; Soil Chem. and Bact., N. J. Expt. Sta., '01—; Asst. Prof. Agr., Rutgers, '06–'07; Assoc.,

do., '07–'10; Prof. Soil Chem. and Bact., '10—; Dir., N. J. Expt. Stas., '11—.

1911. Edward Read Lloyd, B. S. (Ala. Poly. Inst., '87), M. S. (do., '88); *Agricultural College, Miss.;* Prof. Agr., Miss. Agr. Coll., '00–'05; Dir. Farmers' Insts., do., '06–'10; Vice Dir. and Anim. Husb., Miss. Expt. Sta., '10–'12; Dir., do., '12—.

1911. Charles Alfred Lory, B. Ped. (State Normal School, Greeley, Col., '98), B. S. (Univ. Col., '01), M. S. (do., '02), LL. D. (do., '09); *Fort Collins, Col.;* Asst. in Physics, Univ. Col., '99–'02; Prin. Cripple Creek High School, '02–'04; Acting Prof. Physics, Univ. Col., '04–'05; Prof. Physics and Elect. Engin., Col. Agr. Coll., '07–'09; Pres., do., '09—.

1899. Robert Hills Loughridge, B. S. (Univ. Wis., '71), Ph. D. (do., '76); *Berkeley, Cal.;* Asst. Prof. Chem., Univ. Miss., '72–'74; Asst. State Geol. Miss., '72–'74; do., Ga., '74–'78; do., Ky., '82–'85; Prof. Agr., Chem., S. C. Coll., '85–'90; Asst. Prof. Agr. Chem. and Geol., Univ. Cal., '91–'08; Assoc. Prof., do., '08–'09; Emeritus Prof. Agr. Chem., do., '09—.

1901. Thomas Lyttleton Lyon, B. S. A. (Cornell Univ., '91), Ph. D. (Göttingen, '94); *Ithaca, N. Y.;* Instr. Chem., Univ. Nebr., '91–'93; Asst. Chem., Nebr. Expt. Sta., '94–'95; Assoc. Prof. Agr., Univ. Nebr., '95–'99; Prof. Agr., do., and Assoc. Dir. Expt. Sta., '99–'06; Expt. Agron., Cornell Univ. and Expt. Sta., '06—.

1911. Arthur Gillett McCall, B. S. Agr. (Ohio State Univ., '00); *Columbus, Ohio;* Asst., Bur. Soils, U. S. Dept. Agr., '00–'04; Asst. Prof. Agron., Ohio State Univ., '04–'05; Assoc. Prof. Agron., do., '05–'06; Prof. Agron., do., '06—.

1911. Charles Edward Marshall, Ph. B. (Univ. Mich., '95), Ph. D. (do., '02); *East Lansing, Mich.;* Asst. Bact., Univ. Mich., '93–'96; do., Mich. Expt. Sta., '96–'98; Bact. and Hygienist, do., '98—; Sci. and Vice Dir., do., '08—; Prof. Bact. and Hyg., Mich. Agr. Coll., '03—.

1911. FREDERICK RUPERT MARSHALL, B. S. Agr. (Ontario Agr. Coll., '99), B. S. A. (Iowa State Coll., '00); *Columbus, Ohio;* Asst. Prof. Anim. Husb., Iowa State Coll., '01–'03; Prof. Anim. Husb., Tex. Agr. Coll., '03–'07; Prof. Anim. Husb., Ohio State Univ., '07—.

1911. DAVID WILLIAM MAY, B. Agr. (Univ. Mo., '94), M. Agr. (do., '96); *Mayaguez, P. R.;* Asst. Agr., Missouri Expt. Sta., '97; Sci. Asst., Office Expt. Stas., U. S. Dept. Agr., '00–'02; Anim. Husb., Ky. Expt. Sta., '02–'04; Special Agt. in Charge P. R. Expt. Sta., '04—.

1905. LUCIUS HERBERT MERRILL, B. S. (Univ. Me., '83), D. Sc. (honorary, do., '08); *Orono, Me.;* Chem., Me. Expt. Sta., '86–'08; Prof. Biol. Chem., Univ. Me., '98–'07; Prof. Biol. and Agr. Chem., do., '07—.

1909. MERRITT FINLEY MILLER, B. S. Agr. (Ohio State Univ., '00), M. S. A. (Cornell Univ., '01); *Columbia, Mo.;* Asst. Bur. Soils, U. S. Dept. Agr., '01–'02; Instr. Agron., Ohio State Univ., '02–'03; Asst. Prof., do., '03–'04; Prof. Agron. and Curator Agr. Museum, Univ. Mo., '04—.

1910. GEORGE THOMAS MOORE, B. S. (Wabash Coll., '94), A. B. (Harvard Univ., '95), A. M. (do., '96), Ph. D. (do., '00); *Missouri Botanical Garden, St. Louis, Mo.;* in charge Bot. Dept., Dartmouth Coll., '99–'01; Physiol. and Algologist, Bur. Plant Indus., U. S. Dept. Agr., '01–'02; in charge Lab. Plant Physiol., do., '02–'05; Prof. Plant Physiol. and Applied Bot., Shaw School of Bot., Mo. Bot. Gard., '09—.

1900. JOHN HARCOURT ALEXANDER MORGAN, B. S. A. (Univ. Toronto, '89); *Knoxville, Tenn.;* Prof. Ento. and Hort., La. State Univ., '89–'93; Prof. Zool. and Ento., do., '93–'04; Ento. La. Expt. Stas., '89–'04; Dir. Gulf Biol. Sta., '99–'05; Dir. Tenn. Expt. Sta., '05—.

1911. FRED WINSLOW MORSE, B. S. (Worcester, '87), M. S. (do., '00); *Amherst, Mass.;* Asst. Chem., Mass. Expt. Sta., '87–'88; do., N. H. Expt. Sta., '88–'89; Chem., do., '89–'09; Vice-Dir., do., '96–'09; Prof.

Chem., N. H. Agr. Coll., '90–'09; Research Chem., Mass. Expt. Sta., '10—.

1909. Frederick Blackmar Mumford, B. S. (Mich. Agr. Coll., '91), M. S. (do., '93); *Columbia, Mo.;* Asst. Mich. Expt. Sta., '91–'95; Asst. Prof. Agr., Mich. Agr. Coll., '93–'95; Prof. Agr., Univ. Mo., '95–'04; Acting Dean Coll. Agr., Univ. Mo., and Acting Dir. Mo. Expt. Sta., '03–'05; Prof. An. Husb., Univ. Mo., '04—; in charge An. Husb. Dept., Mo. Expt. Sta., '06; Dean Agr. and Dir. Expt. Sta., '09—.

1901. Herbert Windsor Mumford, B. S. (Mich. Agr. Coll. '91); *Urbana, Ill.;* Instr. Mich. Agr. Coll., and Asst. Expt. Sta., '95–'96; Asst. Prof. Agr. and An. Husb., do., '96–'99; Prof. Agr., do., '99–'01; Prof. An. Husb., Univ. Ill., and Chief in An. Husb., Ill. Expt. Sta., '01—.

1893. Herbert Osborn, B. S. (Iowa State Coll., '79), M. S. (do., '80); *Columbus, Ohio;* Asst. Zool. and Ento., Iowa State Coll., '79–'83; Asst. Prof., do., '83–'85; Prof., do., '85–'98; Prof. Zool. and Ento., Ohio State Univ., '98—.

1893. Louis Herman Pammel, B. Agr. (Univ. Wis., '85), M. S. (do., '89), Ph. D. (Wash. Univ., '99); *Ames, Iowa;* Asst. Shaw School of Bot., '86–'89; Tex. Agr. Expt. Sta., '89; Prof. Bot., Iowa State Coll., '89—; Bot. Iowa Expt. Sta., '92—.

1893. Henry Jacob Patterson, B. S. (Pa. State Coll., '86); *College Park, Md.;* Asst. Chem. Pa. Expt. Sta., '86–'88; Chem. Md. Expt. Sta., '88–'98; Dir. and Chem., do., '98—.

1910. Raymond Pearl, A. B. (Dartmouth Coll., '99), Ph. D. (Univ. Mich., '02); *Orono, Me.;* Asst. Zool., Univ. Mich., '99–'02; Instr. Zool., do., '02–'06; Instr. Zool., Univ. Penn., '06–'07; Biol. and Head Dept. Biol., Me. Expt. Sta., '07—; Assoc. Ed. *Zool. Jahresber.* '06-'08, *Biometrika,* '06–'10, *Zentbl. Allg. u. Expt. Biol.,* '10—.

1909. Raymond Allen Pearson, B. S. A. (Cornell Univ., '94), M. S. A. (do., '99); *Fort Orange Club, Albany, N. Y.;* Asst. Chief Dairy Div., U. S. Dept. Agr.,

'95–'02; Mgr. Walker-Gordon Lab. Co., N. Y. and Phila., '02–'03; Prof. Dairy Ind., Cornell Univ., '03–'07; N. Y. Comr. Agr., '07–'12; Pres. Elect, Iowa State Coll.

1910. WILLIAM ROBERT PERKINS, B. S. (Miss. Agr. Coll., '91); M. S. (do., '94); *Deeson, Miss.;* Asst. State Chem., Miss., '91–'94; Chem., Miss. Expt. Sta., '94–'06; Asst. Prof. Agr., Miss. Agr. Coll., '06; Asst. Prof. Agr., Miss. Agr. Coll., '06; Agron., Miss. Expt. Sta., '07–'10; Dir. Agr. Dept., and Prof. Agron., Clemson Coll., '10–'11; Supt. Syndicate Farm, Deeson, Miss., '11—.

1909. CHARLES VANCOUVER PIPER, B. S. (Univ. Wash., '85), M. S. (do., '92; Harvard, '00); *Washington, D. C.;* Prof. Ento., Wash. State Coll., '92–'93; Prof. Bot. and Zool., do., and Bot. and Ento. Expt. Sta., '93–'03; Syst. Agrostologist, U. S. Dept. Agr., '03–'04; Agrostologist, do., '05—.

1890. CHARLES SUMNER PLUMB, B. S. (Mass. Agr. Coll., '82); *Columbus, Ohio;* Asst. Ed. *Rural New Yorker*, '83–'84; First Asst., N. Y. Expt. Sta., '84–'87; Prof. Agr., Univ. Tenn., and Asst. Dir. Expt. Sta., '87–90; Prof. Agr. Sci., Purdue Univ., '90–'94; Prof. An. Ind. and Dairying, do., '94–'00; Prof. An. Ind., do., '00–'02; Vice Dir. Ind. Expt. Sta., '90–'91; Dir. do., '91–'02; Prof. An. Ind., Ohio State Univ., '02—

1884. FRANK WILLIAM RANE, B. Agr. (Ohio State Univ., '91), M. Sc. (Cornell Univ., '92); *State House, Boston, Mass.;* Hort. and Microscopist, W. Va. Expt. Sta., '92–'95; Prof. Agr. and Hort., W. Va. Univ., '93–'95; Prof. Agr. and Hort., N. H. Coll., '95–'98; Prof. Hort., do., '98–'00; Prof. Forestry and Hort., '00–'06; State Forester, Mass., '06—.

1881. ISAAC PHILLIPS ROBERTS, M. Agr. (Iowa State Coll., '75); *Palo Alto, Cal.;* Prof. Agr. and Dean Agr., Cornell Univ., '73–'94; Dir. Cornell Expt. Sta., '88–'03; Dir. Col. Agr., '94–'03; Prof. Emeritus and lecturer, '03—.

1893. JAMES WILSON ROBERTSON, LL. D. (Toronto Univ., and Queen's Univ., '03; Univ. New Brunswick, '04);

Box 540, Ottawa, Can.; Prof. Dairying, Ontario Agr. Coll., '86–'90; Dairy Comr. Canada and Cent. Expt. Farms, '90–'95; Comr. Agr. and Dairying, '95–'04; Prin., MacDonald Coll., '05–'09; Chairman Royal Com. on Indus. Training and Tech. Ed., '10.

1909. PETER HENRY ROLFS, B. S., M. S. (Iowa State Coll., '91); *Gainesville, Fla.;* Asst. Bot., Iowa State Coll., '91; Ento. and Bot., Fla. Expt. Sta., '92–'98; Bot. and Hort., do., '98–'99; Bot. and Bact., S. C. Expt. Sta., '99–'01; Plant Path. in charge Sub-Trop. Lab., U. S. Dept. Agr., Miami, Fla., '01–'06; Dir. Fla. Expt. Sta., '06—; State Supt. Fla. Farmers' Institutes, '07—.

1911. GEORGE McCULLOUGH ROMMEL, B. S. (Iowa Wesleyan Univ., '97), B. S. A. (Iowa State Coll., '99); *Washington, D. C.;* Expert in Anim. Husb., Bur. Anim. Indus., U. S. Dept. Agr., '01–'05; Anim. Husb., do., '05–'09; Chief, Anim. Husb. Div., do., '10—.

1909. HARRY LUMAN RUSSELL, B. S. (Univ. Wis., '88), M. S. (do., '90), Ph. D. (Johns Hopkins, '92); *Madison, Wis.;* Fellow Univ. Wis., '88–'90; Fellow Univ. Chicago, '92–'93; Asst. Prof. Bact., Univ. Wis., '93–'96; Prof., do., '96–'97; Bact., Wis. Expt. Sta., '93–'97; Dir. State Hygienic Lab., '03–'07; Dean Coll. of Agr. and Dir. Expt. Sta., Univ. Wis., '07—.

1908. EZRA DWIGHT SANDERSON, B. S. (Mich. Agr. Coll., '97), B. S. Agr. (Cornell, '98); *Morgantown, W. Va.;* Asst. State Ento. Md., '98–'99; Ento., Del. Expt. Sta., and Assoc. Prof. Zool., Del. Coll., '99–'02; State Ento. Tex., and Prof. Ento., Tex. A. and M. Coll., '02–'04; Ento., N. H. Expt. Sta., and Prof. Ento. and Zool., N. H. Coll., '04–'09; Dir. N. H. Expt. Sta., '07–'09; Dean Coll. Agr., W. Va. Univ., '10—; Dir., W. Va. Expt. Sta., '12—.

1889. MELVILLE AMASA SCOVELL, M. Sc. (Univ. Ill., '75), M. S. (do., '77), Ph. D. (do., '08); *Lexington, Ky.;* Instr. Chem., Univ. Ill., '75–'77; Asst. Prof. Agr. Chem., do., '77–'80; Prof., do., '80–'82; Special

Agt., U. S. Dept. Agr., '84–'85; Dir. Ky. Expt. Sta., '85—; Dir. Coll. Agr., Ky. State Univ., '10—.

1910. ROBERT SIDEY SHAW, B. S. (Ontario Agr. Coll., '93); *East Lansing, Mich.;* Asst. Agr., Mont. Agr. Coll. and Expt. Sta., '97–'02; Prof. Agr., Mich. Agr. Coll., '02–'08; Dean Agr., do.; and Dir. Expt. Sta., '08—.

1893. THOMAS SHAW, *Buffalo, Mont.;* Prof. Agr., Ontario Agr. Coll., '88–'93; Prof. An. Husb., Minn. Coll., Agr., '93–'03; Ed. *Farmer*, '03–'08; Northwest Ed. Orange Judd Publications, '08—.

1898. JOHN HENRY SHEPPERD, B. Agr. (Iowa State Coll., '91), M. S. A. (Univ. Wis., '93); *Agricultural College, N. Dak.;* Ed. Staff *Orange Judd Farmer*, '93; Prof. Agr., N. Dak. Agr. Coll., and Agriculturist Expt. Sta., '93–'04; Dean and Vice Dir., do., '04—.

1909. JOHN HARRISON SKINNER, B. S. (Purdue Univ., '97); *Lafayette, Ind.;* Asst. Agr., Ind. Expt. Sta., '99–'01; Instr. An. Husb., Univ. Ill., '01–'02; Assoc. Prof. An. Husb., Purdue Univ., '02–'06; Prof., do., '06; Dean Agr. Dept., Purdue Univ., '07—.

1907. CLINTON DEWITT SMITH, M. S. (Cornell Univ., '75); *Piracicaba, Estado de Sao Paulo, Brazil;* Dir. Ark. Expt. Sta., '90; Dir. Minn. Sta. and Prof. Dairy Husb., Univ. Minn., '90–'93; Dir. Mich. Expt. Sta. and Prof. Agr., '93–'08; Dir. and Dean Spec. Course Mich. Agr. Coll., '99–'08; Dir. Escola Agricola Practica, '08—.

1907. HOWARD REMUS SMITH, B. Sc. (Mich. Agr. Coll., '95); *University Farm, St. Paul, Minn.;* Teacher, Tilford Collegiate Acad. and Rock Island High School, '95–'09; Acting Prof. Agr., Univ. Mo., '00–'01; Asst. Prof. An. Husb., Univ. Nebr., '01; Assoc. Prof., do., '02; Prof. do., '03–'12; Anim. Husb., Univ. Minn., '12—.

1899. HARRY SNYDER, B. S. (Cornell Univ., '89); *St. Anthony Park, St. Paul, Minn.;* Asst. Chem., Cornell Univ. Expt. Sta., '90–'91; Asst. Instr. Qual. Anal., do., '89–'90; Prof. Agr. Chem., Univ. Minn., and Chem., Expt. Sta., '91–'09; Chem., Russell Miller Milling Co., '09—.

1909. Andrew McNairn Soule, B. S. (Univ. Toronto, '93), Sc. D. (honorary, Univ. Ga., '10); *Athens, Ga.;* Asst. Dir. Mo. Expt. Sta., '94; Asst. Prof. Agr. and Asst. Agriculturist, Tex. Agr. Coll. and Expt. Sta., '94–'99; Dir. Tenn. Expt. Sta. and Chairman Agr. Faculty, Univ. Tenn., '99–'04; Dean of Agr. and Dir. Expt. Sta., Va. Poly. Inst., '04–'07; Pres. Coll. Agr., Univ. Ga., '07—.

1903. William Jasper Spillman, B. S. (Mo. State Univ., '86), M. S. (do., '89), Sc. D. (do., '10); *Washington, D. C.;* Prof. Sci., Mo. State Normal, '87–'89; Prof. Sci., Vincennes Univ., '89–'91; Prof. Sci., Ore. State Normal, '91–'94; Prof. Agr., State Coll. Wash., '94–'01; Agrostologist U. S. Dept. Agr.,'01–'04; Agriculturist in charge Farm Management, do., '04—.

1911. Frank Lincoln Stevens, B. L. (Hobart, '91), B. S. (Rutgers Coll., '93), M. S. (do., '97); Ph. D. (Univ. Chicago, '00); *Mayaguez, P. R.;* Teacher of Sci., Racine, Coll., '93–'94; do., Columbus, O., High School, '94–'97; Instr. in Biol., N. C. Agr. Coll., '00–'02; Prof. Bot. and Veg. Path., do., '03–'11; Biol., N. C. Expt. Sta., '03–'11; Dean, P. R. Coll. Agr., '12—.

1908. William Alton Taylor, B. S. (Mich. Agr. Coll., '88); *Washington, D. C.;* Asst. Pomol., U. S. Dept. Agr., '91–'01; Pomol. in charge Field Investigations, '01—; Asst. Chief, Bur. Plant Indus., '11—.

1911. Roscoe Wilfred Thatcher, B. Sc. (Univ. Nebr., '98), M. A. (do., '01); *Pullman, Wash.;* Asst. Chem., Nebr. Expt. Sta., '99–'01; Asst. Chem., Wash. Expt. Sta., '01–'03; Chem., do., '03—; Asst. Prof. Chem., State Coll. Wash., '04–'06; Assoc. Prof., do., '06–'10; Prof. Agr. Chem. and Head of Dept. Agr., do., '10—; Dir. Wash. Expt. Sta., '07—.

1907. Charles Embree Thorne, M. Agr. (Ohio State Univ., '90); *Wooster, Ohio;* Dir. Ohio Expt. Sta., '87—.

1910. Edward Gaige Titus, B. S. (Col. Agr. Coll., '99); M. S. (do. '01), D. Sc. (Harvard, '11); *Logan, Utah;* Asst. Dept. Zool. and Ento., Col. Agr. Coll., '00–'01; Field Asst. State Ento., Ill., '01–03; Spec. Agt., Bur. Ento., U. S. Dept. Agr., '03–'07; Prof. Zool. and Ento., Utah Agr. Coll. and Ento., Expt. Sta., '07—.

1901. Charles Orrin Townsend, B. S. (Univ. Mich., '88); M. S. (do., '91), Ph. D., (Leipsic, '97); *Garden City, Kans.;* Prof. St. Johns Coll., Md., '88–'91; Prof. Sci., Wesleyan Coll., Ga., '91–'95; Instr. Bot., Barnard Coll., '98; Prof. Bot., Md. Agr. Coll. and State Plant Path. Md., '98–'01; Path. Bur. Plant Indus., U. S. Dept. Agr., '01–'10; Consulting Agr., U. S. Sugar and Land Co., '10—.

1881. Samuel Mills Tracy, B. A. (Mich. Agr. Coll., '68), M. S. (do., '76); *Biloxi, Miss.;* Asst. Prof. Agr., Mo. State Univ., '77–'80; Prof. Bot. and Hort., do., '80–'87; Dir. Miss. Expt. Sta., '87–'97; Spec. Agt. U. S. Dept. Agr., '97—.

1908. William W. Tracy, Sr., B. S. (Mich. Agr. Coll., '67), M. S. (do., '70), D. Sc. (honorary, do., '07); *Washington, D. C.;* Prof. Hort., Mich. Agr. Col., '70–'72; Supt. of Testing Gardens, U. S. Dept. Agr., '02—.

1894. William Trelease, B. S. (Cornell, '80), D. Sc. (Harvard, '84), LL. D. (Wis., '02; Mo., '03; Wash. Univ., '07); *St. Louis, Mo.;* Prof. Bot., Univ. Wis., '83–'85; Engelmann Prof. Bot. and Dir. Shaw School Bot., Wash. Univ., '85—; Dir. Mo. Bot. Gard., '89–'12.

1907. Alfred Charles True, B. A. (Wesleyan Univ., '73), M. A. (do., '76), Ph. D. (Erskine Coll., S. C., '86); D. Sc. (Wesleyan Univ., '06); *Washington, D. C.;* Prin. High School, Essex, N. Y., '73–'75; Instr. State Normal School, Westfield, Mass., '75–'82; Grad. Stu., Harvard Univ., '82–'84; Instr. Wesleyan Univ., '84–'88; Ed. U. S. Office Expt. Stas., '88–'91; Asst. Dir., do., '91–'93; Dir., do., '93—.

1908. Alfred Vivian, Ph. D. (Univ. Wis., '94); *Columbus, Ohio;* Instr. Phar., Univ. Wis., '94–'95; Asst. Agr. Chem., do., '95–'97; Instr., do., and Asst. Chem., Expt. Sta., '97–'02; Assoc. Prof. Agr. Chem., Ohio State Univ., '02–'05; Prof. Agr. Chem., do., '05—.

1893. Henry Jackson Waters, B. Agr. (Univ. Mo., '86); *Manhattan, Kans.;* Asst. Agr., Mo. Expt. Sta., '87–'91; Prof. Agr., Pa. State Coll., '92–'95; Dean Coll. Agr. and Dir. Expt. Sta., Univ. Mo., '96–'09; Pres., Kans. State Agr. Coll., '09—.

1910. Herbert John Webber, B. Sc. (Univ. Nebr., '89); M. A. (do., '90), Ph. D. (Wash. Univ., St. Louis, '00); *Ithaca, N. Y.;* Asst. in Bot., Univ. Nebr., '89–'90; Asst., Shaw School of Bot., '90–'92; Physiol. U. S. Dept. Agr., '92–'97; in charge Plant Breeding Lab., do., '97–'07; Prof. Expt. Plant Breeding, Cornell Univ., '07—.

1889. Clarence Moore Weed, B. S. (Mich. Agr. Coll., '83), M. S. (do., '84), D. Sc. (Ohio State Univ., '89); *Lowell, Mass.;* Asst. State Ento., Ill., '86–'88; Ento., Ohio Expt. Sta., '88–'91; Prof. Zool. and Ento., N. H. Coll., and Ento., Expt. Sta., '91–'04; Nature Study Work, State Normal School, Lowell, Mass., '04—.

1896. Julius Buell Weems, B. Sc. (Md. Agr. Coll., '88), Ph. D. (Clark Univ., '94); *South Boston, Va.;* Instr. Chem. and Math., Md. Agr. Coll., '88–'89; Con. Chem., do., '91–'92; Prof. Agr. Chem. and Chem. Expt. Sta., Iowa State Coll., '95–'04; Industrial Chem., '04—.

1904. Homer Jay Wheeler, B. Sc. (Mass. Agr. Coll. and Boston Univ., '83), Ph. D. (Univ. Göttingen, '89), D. Sc. (Brown, '11); *Kingston, R. I.;* Asst. Chem., Mass. Expt. Sta., '83–'87; Chem., R. I. Expt. Sta., '89–'08; Prof. Geol., R. I. Coll., '89—; Prof. Agr. Chem., do., '03–'10; Acting Pres., do., '02–'03; Dir. Expt. Sta., do., '01—; Agron., do., '05—.

1889. Milton Whitney, *Washington, D. C.;* Asst. Chem., Conn. Expt. Sta., '83; Supt. Expt. Farm, N. C. Expt.

Sta., '86–'88; Prof. Agr., S. C. Coll., and Vice Dir. Expt. Sta., '88–'91; Soil Physicist, Md. Expt. Sta., '91–'94; Prof. Soil Physics, Md. Agr. Coll., '94–'01; Chief Bur. Soils, U. S. Dept. Agr., '94—.

1898. JOHN CHARLES WHITTEN, B. S. (S. Dak. Agr. Coll., '91), M. S. (do., '99), Ph. D. (Univ. Halle, '02); *Columbia, Mo.;* Instr. in Hort. and Hort. Expt. Sta., S. Dak. Agr. Coll., '92; Asst. in Hort., Mo. Bot. Gard., '93–'94; Prof. Hort. and Hort. Expt. Sta., Univ. Mo., '94—.

1908. EDWARD JAMES WICKSON, A. B. (Hamilton Coll., '69), A. M. (do., '72); *Berkeley, Cal.;* Journalist until '79; Lecturer on Agr., Univ. Cal., '79–'91; Assoc. Prof. Agr., do., '91–'97; Prof. Agr., do., '98— Dean Coll. Agr., Univ. Cal., and Dir. Expt. Sta., do., '07—.

1911. JOHN ANDREAS WIDTSOE, B. S. (Harvard Univ., '94), Ph. D. (Univ. Göttingen, '99); *Logan, Utah;* Chem., Utah Expt. Sta., '94–'05; Prof. Chem., Utah Agr. Coll., '95–'05; Dir. Utah Expt. Sta., '00–'05; Dir. School of Agr., Brigham Young Univ., '05–'07; Pres., Utah Agr. Coll., '07—.

1908. HARVEY WASHINGTON WILEY, A. B. (Hanover, '67), M. D. (Indiana Med. Coll., '71), B. S. (Harvard, '73), Ph. D. (Hanover, '76), LL. D. (do., '98); *Washington, D. C.;* Prof. Chem., Butler, '73–'74; Prof. Chem., Purdue Univ., '74–'83; State Chem., Ind., '81–'83; Chief, Div. Chem., U. S. Dept. Agr., '83–'01; Chief, Bur. Chem., do., '01—'12.

1908. CARLOS GRANT WILLIAMS, *Wooster, Ohio.;* Agron., Ohio Expt. Sta., '03—.

1911. WILLIAM ALPHONSO WITHERS, A. B. (Davidson Coll., '83), A. M. (do., '85); *West Raleigh, N. C.;* Asst. Chem., N. C. Expt. Sta., '84–'88; Prof. Chem., N. C. Agr. Coll., '89—; Statis. Agt. U. S. Dept. Agr., '95–'02; Acting Dir., N. C. Expt. Sta., '97–'99; Chem., do., '97—.

1909. FRITZ WILHELM WOLL, B. S. (Royal Frederiks Univ., Christiana, '82), Ph. D. (do. '83), M. S. (Univ. Wis., '86), Ph. D. (do., '04); *Madison, Wis.;* Asst.

Chem., Wis. Expt. Sta., '87–'97; Chem., do., '97—; Asst. Prof. Agr. Chem., Univ. Wis., '93–'04; Assoc. Prof., do., '04–'06; Prof., do., '06—.

1903. Albert Frederick Woods, B. Sc. (Univ. Nebr., '90), A. M. (do. '92); *University Farm, St. Paul, Minn.;* Asst. Bot., Univ. Nebr., '91–'94; Asst. Chief Div. Veg. Path., U. S. Dept. Agr., '94–'00; Chief, do., '01–'09; Chief Path. and Phys., Bur. Plant Indus., and Asst. Chief of Bur., '01–'09; Dean, Coll. of Agr., Univ. Minn., and Dir. Expt. Sta., '10—.

1903. Charles Dayton Woods, B. S. (Wesleyan Univ., Conn., '80) D. Sc. (honorary, Univ. Me., '05); *Orono, Me.;* Asst. Chem., Wesleyan Univ., '80–85; Instr. Sci., Wilbraham Acad., Mass., '83–'88; Chem., Conn. Storrs Expt. Sta., '88–'96; Vice Dir., do., '89–'96; Prof. Agr., Univ. Me., '86–'03; Dir. Maine Expt. Sta., '96—.

1911. Bonney Youngblood, B. S. (Tex. Agr. Coll., '02), M. S. (do., '07); *College Station, Tex.;* Prin. and Instr. in Agr., Henderson, Tex., City Schools, '03–'05; Prin. and Instr. in Agr., Mineola, Tex., High School, '05–'06; Supt. City Schools and Instr. in Agr., Pauls Valley, Okla., '06–'07; Asst. Agr., Office of Farm Management, U. S. Dept. Agr., '07–'11; Dir., Tex. Expt. Sta., '11—.

1910. C. A. Zavitz, B. Sc. (Toronto Univ., '88); *Guelph, Canada;* Asst. Expt. Dept., Ontario Agr. Coll., '86–'93; Head of Expt. Dept., '93—; Prof. of Field Husbandry, Ontario Agr. Coll., '04—.

Deceased Members.

Robert Fairchild Kedzie,	Born	Dec.	9,	1852	Died	Feb.	13,	1882
Lauren Briggs Arnold,	"	Aug.	13,	1814	"	Mar.	7,	1888
George Hammel Cook,	"	Jan.	5,	1818	"	Sept.	22,	1889
Patrick Barry,	"	May	24,	1816	"	June	24,	1890
John J. Thomas,	"	Jan.	8,	1818	"	Feb.	22,	1895
Charles Valentine Riley,	"	Sept.	18,	1843	"	Sept.	14,	1895
Charles Lee Ingersoll,	"	Nov.	1,	1844	"	Dec.	15,	1895
Edward Louis Sturtevant,	"	Jan.	23,	1842	"	July	30,	1898
Sir John B. Lawes, *Hon. Mem.*,	"	Dec.	28,	1814	"	Aug.	31,	1900
John Alvah Myers,	"	May	29,	1853	"	April	8,	1901
Sir Henry Gilbert, *Hon. Mem.*,	"	Aug.	1,	1817	"	Dec.	23,	1901
Robert Clark Kedzie,	"	Jan.	28,	1883	"	Nov.	27,	1902
Victor Hunt Lowe,	"	Sept.	23,	1869	"	Aug.	27,	1903
Henry English Alvord,	"	Mar.	11,	1844	"	Oct.	1,	1905
Robert Warington, *Hon. Mem.*,	"	Aug.	22,	1838	"	Mar.	20,	1907
Willis Grant Johnson,	"	July	4,	1866	"	Mar.	11,	1908
James Fletcher,	"	Mar.	28,	1852	"	Nov.	8,	1908
Samuel William Johnson	"	July	3,	1830	"	July	21,	1909
William Henry Brewer,	"	Sept.	14,	1828	"	Nov.	2,	1910
Charles Anthony Goessmann,	"	June	13,	1827	"	Sept.	1,	1910
Samuel B. Green,	"	Sept.	15,	1859	"	July	11,	1910
Welton M. Munson,	"	April	8,	1866	"	Sept.	9,	1910
Edward Burnett Voorhees,	"	June	22,	1856	"	June	6,	1911
Franklin Hiram King,	"	June	8,	1848	"	Aug.	4,	1911
Oskar Kellner, *Hon. Mem.*,	"	May	13,	1851	"	Sept.	22,	1911
John Bernhardt Smith,	"	Nov.	21,	1858	"	Mar.	13,	1912

SOCIETY FOR THE

PROMOTION OF AGRICULTURAL SCIENCE

PROCEEDINGS

OF THE

THIRTY-THIRD ANNUAL MEETING

ATLANTA, GA., NOVEMBER 12, 1912

PUBLISHED BY THE SOCIETY
1913

Proceedings

OF THE

Thirty-third Annual Meeting

OF THE

Society for the Promotion

OF

AGRICULTURAL SCIENCE

HELD AT

Atlanta, Ga.

November 12, 1912

Edited by the Secretary

E. W. ALLEN

Published by the Society

1913

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CONTENTS.

The Atlanta Meeting, 1912.

By E. W. Allen,
Secretary-Treasurer.

The thirty-third annual meeting of the Society was held at Atlanta, Ga., November 12, immediately preceding the annual convention of the Association of American Agricultural Colleges and Experiment Stations. The sessions were held in the Piedmont Hotel.

The American Society of Agronomy also met at the same time and arrangements were made for several joint seesions with that Society. The first of these was on the evening of November 11, when the members of the Society for the Promotion of Agricultural Science were invited to attend the session of the American Society of Agronomy. Many of the members attended and participated in the session. The afternoon session on November 12 was also a joint session, the program being especially arranged to interest agronomists, and the American Society of Agronomy attending and participating. The latter Society held no session that afternoon on account of this joint arrangement. The evening session of November 12 was given over to a joint meeting of the two societies, at which the presidential addresses were delivered. Director Charles E. Thorne, a member of both societies, presided at this joint session.

The presidential address of Dean E. Davenport, of this Society, was on Obstacles to Progress in Agricultural Science (see page 11), and that of Prof. R. W. Thatcher, of the American Society of Agronomy, dealt with the Relation of Research to Demonstration Work in Agriculture. This discussed in a thoughtful and helpful way a topic which is commanding much attention, and has become an important matter of organization and administration.

The success of these meetings made the advantages of such joint sessions again manifest. They added to the interest of the meetings of both societies, and enabled a larger number

of persons to hear the papers which were of mutual interest. In addition to the presidential address eleven papers were presented at the sessions of the Society. These are given in the following pages. As no stenographer was available for the meeting it was impossible to report the discussion of the papers, which was frequently quite active.

BUSINESS MEETING.

The secretary reported that during the year the Society had lost two members by death, Dr. M. A. Scovell, of Kentucky, and Dr. John B. Smith, of New Jersey, and one member by resignation. During the year twenty-two members elected at the Columbus meeting accepted membership, making the total enrollment at the time of the meeting one hundred and thirty-five regular members and one honorary member. At the meeting the names of ten candidates for membership were presented and approved, all but one of whom have accepted membership. The list of new members is as follows: Prof. A. W. Blair, Associate Soil Chemist, New Jersey Experiment Stations; Dr. W. L. Howard, Professor of Horticulture, University of Missouri; Prof. J. C. Kendall, Director of the New Hampshire Experiment Station; Dr. C. B. Lipman, Soil Bacteriologist of the California College and Station; Prof. W. J. Morse, Plant Pathologist of the Maine Station; Prof. W. G. Sackett, Bacteriologist of the Colorado Experiment Station; Mr. J. F. Voorhees of the U. S. Weather Bureau and Tennessee Experiment Station; Prof. J. T. Willard, Chemist, Kansas Agricultural College and Experiment Station; and Mr. C. B. Williams, Agronomist of the North Carolina Experiment Station. This brings the regular membership up to one hundred and forty-four.

The treasurer's report, submitted by E. W. Allen, was as follows:

Report of Treasurer, 1911–1912.

Cash on hand November 15, 1911	$72.46
Receipts from annual membership dues	244.10
Receipts from Assistant Custodian	250.00
Interest on bank deposit	4.83
Carried forward	$571.39

Balance and receipts brought forward	$571.39	....
Printing Proceedings of thirty-second meeting	....	$211.00
Illustrations for same	....	9.70
Artist for retouching photo	....	.50
Printing letter heads, announcements, and programs	....	11.25
Contribution to International Commission on Agriculture as per vote of the Society at last meeting	....	5.00
Expenses of Dr. W. J. Beal, Custodian	....	8.79
Postage	....	17.89
Stationery, etc	....	2.18
Freight and drayage	....	.90
Balance on hand November 9, 1912	....	304.18
Total	$571.39	$571.39

This account was audited by Dr. C. D. Woods and Prof. W. R. Dodson.

The statement of the assistant custodian, Prof. W. D. Hurd, was as follows:

Report of Assistant Custodian from November 1, 1911, to November 1, 1912.

Receipts from sale of Proceedings:			
College of Hawaii	$15.99		
Vermont State Library	15.50		
Yale University Library	1.59		
Minnesota Public Library	15.50		
Carnegie Library, Pittsburgh	15.50		
Cleveland Public Library	15.50		
Clark University Library	15.50		
Boston Public Library	15.00		
New York State Library	15.50		
University of Illinois	.50		
New York Public Library	.50		
Pennsylvania State College	9.50		
University of Vermont	7.50		
Larrowe Milling Company, Detroit	.50		
		$144.08	
Cash on hand November 1, 1911		141.72	
Letter heads and envelopes		....	$14.41
Plain paper and three stencils		....	.64
Twine		....	.13
Postage		....	.39
Receipt book		....	.25
Paid to treasurer of Society, April 27, 1912		....	250.00
Balance on hand		....	19.98
		$285.80	$285.80

On the outstanding accounts, bills receivable amounting to $30.09 and bills payable amounting to $1.75 were reported, making an additional balance due the Society of $28.34. During the year two hundred and eight volumes of the Proceedings were sold at fifty cents each, and thirty-three volumes at $1.00 each, the prices previously fixed by the Society. An inventory submitted with the report showed that the assistant custodian had on hand November 1, 1912, 5,265 copies of the Society's Proceedings, which at the prices fixed would have a total value of $2,678.50.

In view of the value of the property in the hands of the assistant custodian, the recommendation was made that he should arrange to have it insured for a reasonable amount, and this was voted by the Society. (The property has since been insured for $2,400.)

The secretary reported that, acting under authority of the last meeting, he had represented the Society on the supervisory board of the American Year Book, and with the assistance of a number of specialists had contributed the review upon Agriculture for the 1912 issue of the Year Book. In January, 1912, he attended a meeting of this board in New York City (without expense to the Society), at which the plans for the current year were discussed and also for the Dictionary of American Bibliography, which the board has in contemplation.

Little progress was reported in the matter of the formation of an affiliation of societies of agricultural science, which has previously been under consideration. The secretary wrote to several of the societies which have joined the affiliation, in an attempt to arrange for meetings at Atlanta, but only one society, the American Society of Agronomy, was able to make such an arrangement. The joint meetings with that Society constitute the only product of the affiliation.

The Society voted to renew its contribution to the International Commission of Agriculture, in accordance with its previous acceptance of membership in the Commission, and authorized the secretary to contribute the annual fee of $5.00. The dues of the Society were continued at $2.00.

A committee on resolutions, consisting of Prof. Charles E. Thorne and Dean E. D. Sanderson, presented the following resolutions on the death of two members of the Society:

"It is our sad duty to record the death, during the year just passed, of two of the honored members of this Society.

"Director M. A. Scovell, who died August 15, 1912, was one of those longest in service in the work of agricultural research in this country. He was one of the organizers of the Association of American Agricultural Colleges and Experiment Stations, and had exercised a most helpful influence in molding its policy. He was elected president of the Association in 1908.

"As a member of that Association and of the Society for the Promotion of Agricultural Science he was held in the highest esteem by his co-workers, who found in him a safe and conscientious adviser, and a genial and steadfast friend, standing always for the highest conceptions of duty and honor.

"He has departed from our midst, but the work he did for the agriculture of his adopted state and of the nation at large, and the ties of a closer brotherhood which his kindly spirit has woven amongst us all, will remain an imperishable monument to his memory.

"Dr. John Bernhardt Smith died at New Brunswick, N. J., March 12, 1912. For nearly a quarter of a century Dr. Smith had been entomologist of the New Jersey Agricultural Experiment Station, and for many years had also been State Entomologist of New Jersey. Dr. Smith had an international reputation both as one of the ablest economic entomologists in America and also as a systematist, particularly in the Lepidoptera, Noctuidæ. He was one of a small group of the older entomologists of the present generation who have had the largest influence in developing the science of economic entomology. His advice and aid were eagerly sought by younger workers and were freely given. Ever independent, but always genial, he was an able counsellor. In late years he had become a leading authority on mosquito control, and had already commenced to see the results of the large work he had inaugurated in New Jersey. In his death this Society loses a true scientist, whose heart and life were devoted to his profession as applied to agriculture.

"Whereas, in the death of Melville Amasa Scovell and John Bernhardt Smith, the Society for the Promotion of Agricultural Science has lost two of its most able and loyal members,

whose lives have been devoted to the advancement of its purposes, therefore be it

"*Resolved,* That this Society express its high appreciation of their character, life, and work, and extend to the bereaved families its sincere sympathy, and be it further

"*Resolved,* That a copy of these resolutions be sent to the families of the deceased and be spread upon the minutes of the Society."

These resolutions were adopted by the Society by a rising vote.

An invitation to hold the meeting in 1915 at San Francisco, in connection with the Pan-American Exposition, was presented by the secretary. No action was taken on the invitation, as it was stated that the Society would probably be influenced by the decision of the Association of American Agricultural Colleges and Experiment Stations as to the meeting place in that year. The place of meeting in 1913 was left to the executive committee.

The following officers were elected for the ensuing year: President, Dean E. Davenport, Urbana, Ill.; secretary-treasurer, E. W. Allen, Washington, D. C.; member of the executive committee for three years, Dr. W. H. Jordan, Geneva, N. Y. The motion was made and passed that the office of vice-president be created and President H. J. Waters of Manhattan, Kans., was elected to that office.

Obstacles to Progress in Agricultural Science.

PRESIDENT'S ADDRESS.

By E. Davenport,
Illinois College of Agriculture and Experiment Station.

All science is new, agricultural science in particular. All science is complicated and difficult, none quite so much so as this. Agricultural science, more than any other, depends for its benefits upon its wide application to the affairs of man; but in no other branch of science is that application so difficult, partly because of the complicated nature of agriculture, partly because so many people are included, and partly because they are so scattered and difficult to reach, not being organized into large industrial units. Yet the development of this science is the job we have set ourselves, and we may well spend a few moments in reviewing some of the difficulties and dangers that do beset us.

Yes, science is new. It is so new that for a considerable time to come, as in the past, a goodly portion of our time and funds must be expended in developing, not agricultural, but general science. Especially is this true along the lines of physiological chemistry, biology, and economics. Because of this, agriculture will go down into history, not only as the handmaid of science, but as one of its foster mothers.

In many lines of science the investigator is able absolutely to isolate and control conditions. It is not so with us. Most of the problems of agriculture lie in the field or the barn, subjected to the utmost variety of internal and external conditions, chiefly climatic, and as such, practically beyond control either of the experimenter seeking to discover a principle or the farmer endeavoring to make its application.

The chief object in mentioning a matter of this kind is to invite a little more care in interpreting results of experiments. We are losing much time and producing some bad literature by reason of the fact that so many experimenters feel obliged to

make their investigations conclusive. They too often attempt to reduce the conditions surrounding the experiment to the particular influences they have in mind, and then, when the data fail to show definite results, they resort to the method of "averaging." A paper might be written upon the elusive deceptions of the mathematical average and the need for cold-blooded discussion of actual data.

Another difficulty under which we labor is the obligation to make the application of whatever facts and principles we do discover to the practice of farming. This is always more trying and sometimes more difficult than the original discovery of the principle. Besides, it often occurs that in making the application we disprove what we had before proved in the experiment. This, too, is embarrassment and vexation of spirit to the investigator, but it is salvation to the farmer, and, besides, keeps much bad science out of our permanent literature.

We are suffering from an undersupply of trained and experienced men. Nobody is responsible for this condition: it lies in the situation. The rise of agricultural science and, indeed, of all sciences, from nothing within half a century; the tremendous call for men for both research and teaching, with almost no means of preparation except where the subject is slowly evolving out of chaos—these and a dozen other facts sufficiently explain why it is that up to date we are greatly undermanned, and the marvel is that the standards have been so high and the work so well done. It speaks volumes for the younger men who have carried the burden of the work, as it does for their relations with the pioneers. It speaks other and greater volumes for the future of agricultural science.

The younger men, most of whom are seeking graduate work, find the greatest difficulty in securing it along profitable lines. It could not well be otherwise. We have done well to develop as fully as we have developed a four-years' undergraduate course, not to speak of two or three years' additional training for the specialist. We have need of great discrimination at this point. The young man naturally and rightly desires a degree for his work, and he often finds himself obliged to sacrifice the work he really most needs or else sacrifice the degree. Under that alternative, I most decidedly

advise the latter sacrifice. He can go through the world and do his work if he have the knowledge, but a degree by itself means nothing except a possible slight and temporary personal advancement. We shall all be glad when the time shall come that brings favorable opportunities for graduate work in strictly agricultural science.

In the meantime, and afterward, we need to avoid what would be perfectly easy; namely, the building up of a body of science and of scientists within the field of agricultural materials, yet with little or no reference to the farm. Nutrition experiments are valuable to agriculture only as they eventuate in cheaper and better animal or vegetable products, and the same may be said of breeding. We have done well in the past in at least keeping close to the farm. I trust that the tradition will be preserved as we develop real agricultural science in a finished form.

We cannot close our eyes to the fact that not all influences extant have been healthy for agricultural science. We have had the quack in our business outside the poultry yard. We have had the patent medicine man in agriculture who advertised himself by means of startling articles in the press, by flamboyant addresses at institutes, and sometimes, I am sorry to say, by misleading publications from the experiment stations. Happily their number has been growing less; but with the recent and wholesale demand for extension work, they are due to flare up again like a smothered fire in an old chopping. Just now, in connection with the county specialist plan, scores of unsuccessful doctors and merchants prick up their ears and write to the agricultural college to ask how long it it would take them to brush up for agricultural experts at $3,000 a year.

Such men never fail to remind us that they have been unsuccessful in business, generally on account of their health, and they always emphasize the fact that they were "born on the farm." So is the donkey, and one is about as fit as the other to advise farmers. It reminds me of the woman who insisted that she ought to know how to raise children, having buried seven. We are bound to have much spreading round of bad science by influences arising in this direction. Haply it may not deluge the colleges and stations while the storm passes.

The general demand for extension work in this and other forms is almost certain to operate against the most healthy development of agricultural science. The correct application of a newly discovered principle and its successful incorporation into the practices of the country is about as difficult a proposition scientifically as the original discovery, and while perhaps it may call for a somewhat different type of man than the laboratory investigator, yet in all essential respects the one should be as well trained and as carefully as the other.

The man on the lecture platform or the adviser in the field, away from the surroundings and the restraining and steadying influences of the laboratory, labors under the temptation to substitute opinion for fact when knowledge runs low. In this way some excellent young men, the best native material, have been practically destroyed both for station and for college work—a calamity that ought to be reduced to the lowest possible proportions.

What is less serious for men, but not less unfortunate for agricultural science, is the feeling abroad that the good extension man must of necessity be a ready talker and in possession of a wide range of expert knowledge.

Extension work came prominently before our attention in the palmy days of the farmers' institute, and then the extension man was practically a successful lecturer. Recently, however, the business of the resident specialist has developed and the old-time institute is waning. Whether we are to maintain two distinct forms of extension work, the lecturer and the demonstrator, or whether the second is gradually to supersede the first, is as yet an open question; but in either case the man who undertakes to disseminate agricultural science must be exceedingly careful about the matter or he is likely to do more damage than good to agriculture and bring an everlasting stigma upon agricultural science. In the beginning we feared that a fundamental obstacle to good scientific work would be the premature demands of the farmers impatient for results. Fortunately these fears have not been generally realized.

The farmers have been exceedingly reasonable, not to say patient with us. The test, however, is yet to come as the young men we have trained go out upon the farms. Their

judgment will be final, and I am one who feels that the real test of both stations and colleges is yet to come. The easy work has been done; the exacting service yet awaits us.

Agricultural science is being developed almost entirely by public funds. This is both fortunate and unfortunate. It is fortunate in that larger amounts are available and progress has been more rapid than would have been possible under any other form of support. It is proving unfortunate from a wholly unexpected direction, creating obstacles to progress that are not only sometimes outrageous but often insurmountable.

These obstacles are encountered in the form of restrictive legislation, either statutory or administrative; and conditions are reaching a point at which it is difficult and sometimes impossible to do business, because of the rapidly accumulating mass of laws, decisions, rulings, and opinions, overlapping and interlacing one another until the only road open to action is an exceedingly devious and often doubtful subway.

These laws, rulings, decisions, and opinions are all restrictive. They are designed not to facilitate business but to prevent it. So the administrative obstacles accumulate and settle down like a wet blanket upon the work of the scientific bureaus at Washington and the stations of many of the states. An appropriation bill is passed with numerous and various provisions as to how the funds may not be spent. Other bills, having no relation to our work, carry riders whose interpretation under the ruling of some administrative officer effectively stops activities of long standing and of exceeding great public consequence. Still other bills are passed. Other riders are added. Other rulings and interpretations follow. Commissions and boards are imposed. More restrictions are announced—always restrictions. Opinions and rulings pile up: always pile up, for there is no machinery for their removal.

Finally there accumulates such a mass of this administrative junk officially known as red tape that no private business could live for a month under it. When this condition is reached more time is spent in finding a way to do business without getting into jail than would suffice to do it under normal circumstances. Only the clerks have the time to discover the devious roads around, under, or over the interlacing

mass of obstacles; and often they are unsuccessful, for there are other clerks whose business it is to discover and bring to light long-forgotten adverse rulings: besides, there is always the alternative of a new ruling. Oh, our machinery for preventing things, or in any event for making them as expensive and as difficult as possible, is exceedingly well designed.

This association is sometimes facetiously spoken of as the Society for the Prevention of Agricultural Science, but the situation I am sketching is more effective than any society of mere scientists could possibly be. We lack the ingenuity and we do not possess the power to match what is done by way of regulating (?) public business.

It has reached a point in many places where the really responsible officers know little or nothing about how business must be done. That can be known only to the clerks who actually do the public business, or prevent it, according to the office they happen to serve. When scientific work suffers these restrictions, the easiest and the safest way is to do nothing. Thus does the public defeat its own purposes.

This is no idle tale or fanciful picture. Were it fitting to do so in a public place, I could give instances and examples to show what a bar to scientific progress this legalized inefficiency is becoming.

This is not all. Our money looks good to boards of prison industries with inferior stuff to sell at their own price and anxious to report large profits to the state. This, too, is vexation of spirit. It is more than that. This exploitation of scientific bureaus is legalized robbery of a most demoralizing sort.

Our positions, too, look good to a mass of people too inexperienced and incompetent to win and hold positions in well-organized private and commercial enterprises. They prefer work under the slogan of the merit system and the protection of the civil service. The army of incompetency has charged and taken our outer works: how much longer the citadel itself will withstand the siege, no man can tell; but it takes no prophet to foresee that science can never flourish under the methods of ward politicians bent upon a division of the spoils of office.

Imagine Harvard buying prison-made equipment! Think of Rothamsted reports printed under the law at the nearest

penitentiary! Conceive of the Carnegie Institution with scientific assistants or even record keepers or clerks furnished by a civil service commission! If the institutions working under public funds cannot be as free as these representative institutions to do their work in the best way and by the most direct and economic methods, then their days of real usefulness will speedily end, not to speak of their reputation as scientific agencies.

The future of agricultural science ought to be glorious. It has enlisted a small army of capable men honestly trying to benefit agriculture, and it has the confidence of the farmers. No outside bodies, and certainly not its own machinery, should be permitted to destroy its usefulness; but if its future is not to disappoint its friends, then some of the obstacles touched upon must be removed, and it is my opinion that we ourselves will need to take a hand in the process.

Studies in the Toxicity of Cotton-Seed Meal.

By W. A. Withers and B. J. Ray,
North Carolina Experiment Station.

On August 19, 1908, the North Carolina Agricultural Experiment Station began its investigations relating to the toxicity of cotton-seed meal. The investigations have been conducted jointly by the chemical, animal husbandry and veterinary divisions. We began the investigation with the feeding of swine, and these animals have been used to a certain extent since, to confirm other experiments. On November 4, 1908, we began feeding guinea-pigs and on June 2, 1910, rabbits; and during 1911 a calf. For the past two years our work has been mainly with rabbits.

The guinea-pig was substituted for swine because it is less expensive and more susceptible than swine. Later we abandoned the use of this animal in the main, and substituted the rabbit because the post-mortem can be made more easily and more reliably.

Our feeding with rabbits has been naturally and forced, the forced feeding being through a rubber tube, the feed being in solution. The rabbits are allowed pea vines, cabbage leaves and other green feed each morning. When some fraction of the meal is fed the part removed is replaced with wheat bran. We mix molasses with the feed to make it more palatable. Controls are run during the time of the experiment.

The rabbits are fed in cages which are made of galvanized iron. The floors are of galvanized wire and the bottoms are of zinc and funnel-shaped so as to make collections and cleansing easy. Generally our natural feeding was intended to be about in the equivalent of 10 grams daily for every kilogram of initial live weight of the animal. Deductions were always made of the amount of feed refused by the animal each day. The amount eaten, therefore, was very frequently less than this amount, and where the animal was very light the feed consumed was sometimes greater than this amount.

In the experiments various lots of upland cotton seed and meal, fresh and old, were used. The meal was fed by itself, and mixed with bran, with corn meal in different proportions, with linseed meal, with molasses, and with green feed such as cabbages or pea vines. We have also by mechanical means separated the meal into portions, one of which has been designated fines and the other coarse.

Sea Island seed and meal were also fed, the latter being divided into the two fractions of fines and coarse.

We have fed the ash of cotton-seed meal; the ash of cotton-seed meal dissolved in hydrochloric acid, so as to render it more soluble; and this product precipitated by sodium carbonate. We have also fed corn meal, wheat middlings, linseed meal, soy beans, blood, and sodium pyrophosphate.

We have used as solvents water, cold and boiling, potassium hydroxid, acetic acid, 1 per cent hydrochloric acid, 1 per cent sulphuric acid, sodium chloride solution, ammonium citrate solution, and the precipitate and filtrate after treating the hydrochloric solution with a solution of sodium hydroxid. We have also used as solvents ether, chloroform, alcohol, alcohol and actic acid, and alcohol and sodium hydroxid.

We have used also yeast, pepsin, pancreatin, pepsin and pancreatin; and have inoculated the meal as fed to rabbits with the extract of the stomach and of the small and large intestines of a pig dead frcm cotton-seed meal intoxication.

As a result of our work we have found all cotton-seed meal, no matter what its name, age or method of manufacture, to be toxic to guinea-pigs, rabbits, swine and a calf.

Where solvents were used we found the extract of cotton-seed meal to be non-toxic in every case except the pepsin-pancreatin extract fed to rabbits in amounts corresponding to eight or ten times the normal. An extract scientifically prepared and fed to the same kind of animals in amounts corresponding to the normal feed proved to be non-toxic.

All solid residues of cotton-seed meal, no matter whether prepared mechanically or left after the action of solvents, proved toxic to the animals used except one feed, and it was the residue left after treating the meal with an alcoholic solution of sodium hydroxid.

Sodium pyrophosphate was found to be non-toxic to rabbits if fed in amounts corresponding to the phosphorus in our normal feed.

No evidence was found of the presence of toxic alkaloids in the feed, or of hydrocyanic acid in the feed or in the body of animals dead from eating cotton-seed meal.

A study of the urine from rabbits indicates that most of the nitrogen is excreted in the usual forms.

We wish to acknowledge our indebtedness to Mr. R. S. Curtis, animal husbandman, and to Dr. G. A. Roberts, veterinarian, both of whom are connected with this Experiment Station, for valuable assistance and cooperation.

The paper was discussed by Dr. W. H. Jordan and Dr. B. L. Hartwell. Dr. Jordan referred to the possible effect of the heavy protein feeding as having a bearing on the injury observed. Dr. Hartwell described the effect when cotton-seed meal was fed to chickens in comparison with beef scrap. The meal was not found toxic to chickens when fed ad libitum, but the gains were smaller than on beef scrap. It was felt that the protein of the cotton-seed meal was not giving the same returns as that from beef scrap. The possibility of the effect of the ash constituents in cotton-seed meal was suggested.

On the Relation of the Body Weights of Dairy Cows to Their Production.

By F. W. Woll,
Wisconsin Experiment Station.

It is often stated, and is doubtless quite generally believed by dairy farmers and others, that small cows are more economical producers of dairy products than large ones. Heavy cows, it is argued, consume large amounts of feed and do not make as good returns in proportion to the feed which they eat as do small cows. This argument is used especially by partisans of the smaller dairy breeds and with many has become one of the "talking points" in favor of these. It is true that many small cows have been distinguished in the past by a very large production of milk and butter fat, and that this production was made on a moderate ration and at a relatively low feed cost, but the same holds good in the case of heavy cows and to a still larger extent, so far as the production is concerned. Although they were fed considerably heavier rations, as a rule, the returns per unit of feed eaten were also larger in the case of these cows than those obtained from light cows that have been remarkable for their capacity for dairy production.

This has been shown repeatedly in the past, among others by the writer in connection with the results of breed tests conducted at American experiment stations.[1] When the results obtained for the different cows were arranged in groups according to the body weights of the cows, the large cows within the different breeds were found to have the largest yields of milk and butter fat, as well as the smallest feed consumption per unit of milk or butter fat produced, *i. e.*, the opposite result of what is perhaps the prevailing idea as to the relative economy of light and heavy cows as dairy producers.

A competition for dairy cows owned by farmers and breeders of dairy cattle in this state has recently been completed under the direction of the writer, in which nearly 400 yearly records of production of milk, solids and butter fat

[1]Breeders' Gazette, Vol. 38 (1900), p. 379 to 380.

were obtained. The feed eaten by the cows during the record year was also ascertained with a fair degree of accuracy. The results obtained in the competition with discussions have recently been published in bulletin No. 226 and research bulletin No. 26 of the Wisconsin Experiment Station, and reference is here made to these publications for accounts as to the conduct of the competition and the main results obtained therein. We shall here only consider the data secured with reference to the relation between the weight of the cows, their production, and the cost of the latter.

The data for the three breeds represented in the competition, Holsteins, Guernseys and Jerseys, have been compiled according to the body weights of the cows, the weight having as a rule been estimated from measurements of the heart girths of the cows.[1] It was found advantageous to introduce the term *feed unit* in compiling the results of the competition, and this system has been explained in circular of information No. 37 of the Wisconsin Experiment Station. The total value of the products includes the value of the butter fat produced and of the skim milk calculated at 80 per cent of the milk yield.[2]

The compilations are arranged in groups of decreasing body weights for the three breeds given, and at the close of the table the data are combined for all the cows that completed yearly records in the competition for which information as to body weights was secured. This summary, as will be seen, includes data for 355 cows, viz., 145 Holsteins, 135 Guernseys, and 75 Jerseys.

[1]New Hampshire Experiment Station, bulletin No. 4, p. 18; Woll, Handbook for Farmers and Dairymen, 5th edition, p. 35.

[2]Wisconsin Experiment Station, bulletin No. 226, p. 10.

TABLE I.—RELATION OF WEIGHT OF COWS TO PRODUCTION.

Breed and weight.	No. of cows.	Average body weight.	Fat produced.	Cost of feed.	Net returns.	Feed units.	Per 100 feed units: Fat produced.	Per 100 feed units: Value of products.
		lbs.	*lbs.*				*lbs.*	
Holsteins:								
900 lbs. and under	5	880	415.2	$89.05	$47.26	7895	5.26	$1.73
901–1000 lbs.	12	948	481.7	92.95	63.91	7865	6.12	2.00
1001–1100 lbs.	20	1083	479.3	87.76	69.02	7550	6.35	2.08
1101–1200 lbs.	42	1181	479.4	87.69	70.47	7665	6.26	2.06
1201–1300 lbs.	25	1274	529.3	94.44	77.98	8145	6.49	2.12
1301–1400 lbs.	25	1380	524.5	91.31	80.25	8002	6.55	2.14
1401 lbs. and over	16	1556	566.6	96.60	88.01	8364	6.77	2.21
Guernseys:								
900 lbs. and under	39	849	382.0	65.71	53.38	6082	6.28	1.96
901–1000 lbs.	49	956	420.0	69.82	61.31	6273	6.70	2.09
1001–1100 lbs.	26	1066	438.4	74.39	62.81	6717	6.53	2.04
1101–1200 lbs.	15	1155	482.0	73.77	76.31	6627	7.28	2.04
1201 lbs. and over	6	1292	440.8	88.57	49.41	7366	5.98	1.87
Jerseys:								
900 lbs. and under	43	842	346.3	52.10	55.76	5432	6.37	1.99
901–1000 lbs.	21	945	376.0	56.75	60.01	5666	6.64	2.06
1001–1100 lbs.	7	1057	393.0	50.56	71.35	5271	7.46	2.31
1101 lbs. and over	4	1200	419.0	59.03	72.27	6027	6.95	2.18
All breeds:								
900 lbs. and under	87	847	366.2	60.32	54.20	5866	6.24	1.95
901–1000 lbs.	82	952	417.8	69.86	61.36	6351	6.58	2.07
1001–1100 lbs.	53	1071	447.8	76.28	66.28	6858	6.55	2.09
1101–1200 lbs.	60	1175	477.7	82.81	72.21	7331	6.52	2.12
1201–1300 lbs.	31	1276	506.2	91.51	72.01	7875	6.43	2.03
1301–1400 lbs.	26	1379	525.8	92.15	79.64	8051	6.53	2.13
1401 lbs. and over	16	1556	566.6	96.60	88.01	8364	6.77	2.21

A study of the data presented for cows of the different breeds, as well as for all breeds combined, will disclose the fact that in all cases, with but few and unimportant exceptions, the yield of butter fat increased with the average body weight of the cows, and the feed units eaten, the cost of the feed, and net returns(value of products less cost of feed) likewise increased as the weight of the cows increased. Per hundred feed unit eaten there is likewise a larger production of butter fat and a higher value of products secured the heavier the cows are, within the same breeds, as well as on the average for the three breeds.

The cows furnishing the data for the tables were owned by over fifty different farmers and breeders of dairy cattle. The method of feeding and managment of these herds naturally differed greatly as to both the system of feeding followed and the character of feeds which the cows received. Some were heavy feeders and gave their cows the very best of care and attention, in order to obtain a maximum production from them and thus win some of the prizes offered, and get the benefit of the advertisement which the award of these, or the publication of large records would give. Other breeders, on the other hand, were averse to forcing their cows, for fear of injuring their future usefulness in the herd. Some breeders also had had considerable previous experience in feeding cows for large records, while with others this was the first time they had cows officially tested in their herds. It so happens that this differentiation in the practice followed by breeders runs largely by breeds, so that we would not be justified in making strict comparisons between groups of cows of the same body weights within the different breeds. The number of cows included in the different groups also varies greatly, which introduces another factor to be considered bearing on the correctness of comparisons between the average figures obtained for the different groups of cows.

These remarks do not, however, apply in any appreciable degree at least to the summary figures for the groups of cows, including all breeds given at the close of the table. It will be seen that we have here all desirable regularity in the relation between the data for the various groups of cows. This relation will come out still more clearly if the data are calculated

to percentages of the figures given in each column for the group of cows 900 pounds and under. This has been done, with results as shown in the following table:

TABLE II.—RELATION OF DATA FOR COWS OF DIFFERENT BODY WEIGHTS.

Average weight.	Fat produced.	Value of products.	Cost of feed.	Net returns.	Feed units.	Per 100 feed units.	
						Fat produced.	Value of products.
100	100	100	100	100	100	100	100
112	114	115	116	113	108	105	106
126	122	124	126	122	117	105	107
139	130	135	137	133	125	105	109
151	138	143	152	133	134	103	104
163	144	150	153	147	137	105	109
184	155	161	160	162	143	109	113

The results show conclusively that there is, in general, a definite relation between the production of cows of different body weights, the heavier cows being capable of a larger production than light cows; the production is also made more economically as regards the amount of feed eaten, hence the largest net returns are obtained from such cows. The conclusion seems fully warranted, therefore, that farmers and breeders of dairy cattle should aim to keep heavy cows of the particular breed that best suits their fancy and the special purpose in view, as they may then expect with considerable assurance the largest returns, both absolutely and relatively, for the feed eaten by their cows.

This conclusion is only what would be expected from theoretical considerations. A large animal has a relatively smaller body surface than a small animal, and the radiation of heat from the former is therefore proportionately smaller than that from a small animal; hence a larger proportion of the feed eaten by heavy cows is available for milk production, and per unit of feed eaten a larger production is made and greater net returns secured from the herd in the case of such cows. No one would seriously maintain the elimination of the smaller breeds of cattle for this reason, for the question of dairy breeds, as of other improved breeds of farm animals, is a com-

plex one and cannot be decided on the score of production or economy of production alone, but the results presented lead decisively to the conclusion that large animals within a breed are on the whole preferable to small ones and may be depended on, as a general proposition, to make both the largest and the most economical production of dairy products for their owners.

This holds true when the returns from the cows over and above the cost of feed are considered and, to a still greater extent, when account is taken of the total expenses connected with running the dairy, including such items as labor, shelter, machinery and equipment, herd bulls, medicines, depreciation, etc. The expenses other than feed do not vary greatly with animals of different weights and may be placed approximately at about $32 per head annually under good dairy conditions.[1] The figures presented in table I show that a herd of, say thirty cows weighing about 847 lbs. (group I) will yield but little more than one of twenty cows weighing about 1276 lbs. per head (group 5); the feed of both herds will cost approximately the same, viz., $1,809.60 and $1,830.20, but the expenses incurred in operating the dairy other than the feed cost may be estimated at about $960 and $640 for the two herds, making the total annual expenses for the small and the large cows, respectively, $2,769.60 and $2,470.20; the value of products obtained (butter fat and skim milk), would be $3,435.60 and $3,270.40, and the net returns secured from the two herds, therefore, $666 and $800.20.

The figures given are mainly valuable for comparative purposes and are subject to considerable variations according to the value and the production of the cows and the value of their offspring. They may, however, be fairly taken to indicate in a general way the difference in the returns from dairy herds composed of large and of small cows, with a similar aggregate production of butter fat, under modern methods of dairy management.

[1]Minnesota Experiment Station, bulletin No. 124.

Notes on Citrus Investigation in Florida.

By P. H. Rolfs,
Florida Experiment Station.

I. COMMISSION TO FIX A CHEMICAL STANDARD FOR THE DETERMINATION OF MATURITY OF CITRUS FRUITS.

During the year 1911, the Florida legislature, in its biennial session, passed a law prohibiting the sale and transportation of immature citrus fruits. In a general way this law has been spoken of as the "green fruit law." Proper penalties and methods of procedure, as is common in such cases, were a portion of the enactment. The session of the legislature occurred during April and May. At that time there was, of course, no immature citrus fruit in Florida which was at all likely to be shipped, consequently when this law came up before the legislature no one in the state seemed to be particularly interested in amending it or changing it in any way.

During May of that year the Florida Horticultural Society was assembled in annual session at Jacksonville. The question came up on the floor of the Horticultural Society as to what stand the organization would take in reference to the "green fruit law." The matter was discussed to some extent on the floor but there seemed to be no particular enthusiasm against the passage of the law, everybody taking for granted that it would be a good thing to have a law that would prohibit the transportation and sale of immature citrus fruit. A resolution endorsing the proposed law was overwhelmingly carried, and the action of the Society immediately telegraphed to the legislature as a further means of helping along the passage or the green fruit bill.

THE CARRYING-OUT OF THE LAW.

Between the time of the passage of the law and the time that the fruit was maturing on the trees almost nothing was heard in regard to this new law, but when the fruit began to mature in the fall and the earlier varieties were arriving at the point where they were about three-quarters grown, some interest

was manifested as to what would be the effect of the law; and before the earlier varieties were really mature the agitation and discussion rose to about fever heat, the Florida Citrus Exchange being arrayed on the side of enforcing the "green fruit law" and a portion of the independent shippers arrayed on the side of ignoring or setting it aside.

At this juncture a very natural condition became apparent, demonstrating how human nature plays an important part in the regulation of commerce and in the regulation of human action. It was impossible to find anybody in the state who was not in favor of enforcing the "green fruit law" so long as it regulated the shipment of the other man's fruit, but when it came to one's own premises he immediately became the only authority on the question as to what was immature fruit, and if anyone differed as to opinion he was immediately assigned to membership in the Ananias Club. This difference in opinion led to a considerable amount of acrimonious discussion in the papers, and was promptly followed by litigation, shipments of fruit being held up and the owners thereof cited to court, fined, and naturally appealing their cases, thus staying the execution of the law.

When it came to the matter of enforcing this "green fruit law" it soon became apparent that nowhere in law books, court procedure, text-books or scientific works could be found the definition of what was immature fruit. Consequently the courts seemed somewhat powerless in deciding this question, and juries likewise had no great predilection for establishing a line of demarkation between maturity and immaturity.

THE STANDARDIZING COMMISSION.

In July of 1912, Commissioner of Agriculture McRae appointed certain persons of scientific standing as a commission to meet and formulate a definition for mature citrus fruit, or to point out the line of demarcation between mature and immature citrus fruit. This commission consisted of Professor H. H. Hume, president of the Florida State Horticultural Society; State Chemist R. E. Rose; Dr. E. R. Flint, professor of chemistry at the State University; Prof. S. E. Collison, chemist to the experiment station; and P. H. Rolfs, Director of the experiment station.

Immediately upon appointment the various members of the commission consulted literature on this subject, and brought together all the technical information that could be obtained. In addition to the published literature on the subject, the commission had before it sixty-two analyses of oranges made by a private laboratory in Philadelphia and two hundred and eighteen analyses of oranges made by chemists in Baltimore. After holding two meetings and discussing the matter fully, the commission made a report to Commissioner of Agriculture McRae as to its findings. The report had the unanimous approval of the members of the commission. As it was very brief I will give the findings.

"*First.* All round oranges showing a field test of 1.25 per cent or more of acid, calculated as citric acid, shall be considered as immature.

"*Second.* Provided, however, that if the grower (or shipper) consider the fruit mature he shall have the right to appeal from the field test to the State Chemist for a chemical analysis. and if this chemical analysis shows that the percentage by weight of the total sugar, as invert sugar, be seven times or more than the weight of the total acid as citric acid, the fruit shall be deemed mature.

"*Third.* That the juices of not less than 5 average oranges shall be mixed, from which a composite sample shall be drawn for the field test.

"*Fourth.* That the juices of not less than 12 average oranges shall be mixed, from which shall be drawn a composite sample for laboratory analysis."

After securing these findings by the technical men composing the commission, a convention of growers was called, who met in Gainesville, August 15, to receive this report. Previous to the meeting of the citrus growers it had been generally held by those who wished to have a high standard that the ratio of acid to sugar should be one to seven. The commission, therefore, introduced somewhat of a novelty in the report when they found that citrus fruit may be considered mature at any time when the amount of citric acid present in the juice is less than 1.25 per cent. The citrus growers were ready to accept the findings of the commission, but made some amendments to the report of the commission The

following two brief amendments were made, which to some extent changed the findings of the commission, but did not materially alter them.

First amendment. "Resolved, that it is the sense of this Conventon that the report of the Commission shall be adopted, and shall obtain until the 5th day of November in each and every year; provided, that after the 5th day of November in each and every year the standard shall be 'that if each orange is two-thirds its total area colored yellow, it shall be considered as mature and fit for shipment.'"

Second amendment. "That no variety of oranges or grapefruit shall be allowed to be shipped before October 1 of each year that has bloomed during that calendar year."

This, it seems to me, makes a somewhat unique departure from the general way of determining when fruit is mature. I think it is the only time when a state has actually made a chemical standard the basis for determining the maturity of any fruit.

II. CONTROL OF SCALE INSECTS AND WHITEFLY BY PARASITIC FUNGI.

The question of control of insects by means of natural enemies has received much attention, at times attaining to what we might call notoriety. In America the matter has been given probably more serious and systematic study than anywhere else in the world; at least this would seem to be the case from a study of the literature.

Among the workers along this line may be mentioned Doctors Snow, Forbes, and Burrill. Much work has been done by each of these men, but for want of time and opportunity the follow-up work could not be continued, and consequently much of the good has been lost.

In Florida the climatic conditions seem especially favorable to the use of such methods for the control of gregarious insects, especially those belonging to the families Coccidæ and Aleyrodidæ. Insects that lead a more solitary life do not lay themselves open to vulnerable attacks to the same degree as insects that are inclined to be gregarious and live a stationary existence during a portion of their life cycle.

The period of this work in Florida began in about 1894, when Doctor Webber discovered a parasitic *Aschersonia* of the

whitefly *Aleyrodes*. About the same time the writer discovered a fungus *Sphærostilbe coccophila*, parasitic upon San José scale. This discovery was not accidental but was the result of giving a considerable amount of time and study to determine the cause of a natural mortality among San José scale. The observations were published, and were received with an unusual amount of incredulity.

FUNGI WIDELY USED IN FLORIDA.

Nowhere else in the world have fungi been so widely and successfully used for the control of insect pests as in Florida. I have already called attention to the fact that climatic conditions are especially favorable to the spread of insect diseases. Peculiarly enough, the particular forms of insects which are most advantageously controlled in this way are very abundant in the state. The species are numerous and the individuals belonging to the species are likely to be present in excessive numbers when conditions are favorable to their health.

The rainy season occurs in the summer time when the temperature is highest, producing an atmosphere that may be likened to the air in a moist chamber. The condition of growth of the trees is likewise such as to produce an abundance of shade and further reduce the evaporation that would occur from radiation. With the intense sunlight comes abundant development of foliage. The sunlight, however, does not become so severe as to be a deterrent to the development of foliar spread. Under these natural conditions the introduction and dissemination of fungi become an easy matter compared with the conditions in regions where the atmosphere may be dry during the warm portion of the year or cold during the moist portion.

These natural conditions being present and favorable to the growth of fungi, the experiment station has encouraged so far as possible the development of private enterprise for the dissemination of scale and whitefly diseases. During the spring and summer of 1909 one man alone with his helpers treated 127,000 citrus trees with Aschersonia spores to produce diseases among whitefly. This work was done under contract at two cents per tree treated. This, compared with spraying

with insecticides, was a very light cost, since spraying the same trees with insecticides would have cost about twenty-five cents per tree. During 1910–11 we do not have the record as to the number of trees treated, but it would go up into the millions.

The introduction of fungi for scale insects is carried on in a somewhat different way from the introduction of the fungi against whitefly. Diseased scales are introduced into healthy colonies. This can be most easily accomplished by transferring sprigs or pieces of branches upon which diseased scales occur. Placing these in contact or nearly so with the healthy scale readily transfers the disease, while rains, dews and other conditions do the rest.

Naturally in the introduction of diseases there is an opportune and an inopportune time at which to do the work. Under advantageous climatic conditions little difficulty is inexperienced; under adverse climatic conditions the work has to be repeated. The experiment station has carefully worked out the details connected with the successful introduction of the various fungi. At times rather long periods occur when the fungi are not readily introduced, or there may be other conditions existing in the grove which militate against the rapid spread of the insect diseases. During such periods it becomes important to use the ordinary artificial remedial measures.

As these details, together with the names of different species of fungi, as well as the names of the species of host insects, occur in the experiment station bulletins, I will not burden my hearers with reciting them here.

REASONS FOR FAILURES.

The most important and serious reason for failures with our work has been lack of scientific knowledge as to what conditions were favorable and what were unfavorable for the rapid development of diseases among the insects. There is no difficulty in securing the infections, though often in this line the beginner has more or less trouble. After studying the question for a decade and a half or more, and doing so in a technical and systematic way, many facts have been brought together. These can now be so formulated that the average layman can make use of the information. Many times, how-

ever, it is difficult for the non-technical man to understand that the processes must be carried out exactly as directed by the scientific man. The layman will not understand why some other method, some short cut, which apparently accomplishes the same work, will not do just as well.

Another reason for the lack of popularity is the fact that zealous people have over-advertised this method of controlling pests. This is not so likely to be the case with the scientist, since he is likely to under-advertise his discoveries, but the popularizer of scientific material is likely to induce the layman to believe that all he has to do is to introduce the fungus spores and then go away and leave them, and the fungus will do the rest. These same persons would not be likely to advocate that it was possible to raise a citrus grove by simply sowing a few orange seeds here and there in our pine-woods or hammock, yet their imagination leads them to believe that this kind of careless work will be all right with the "invisible."

Under the old methods when the difficulties of securing a large infection were not well understood, it frequently happened that the introduction of the fungi gave negative results, and this naturally led to condemning the method.

OPPOSITION TO THE METHOD.

At first glance it would seem as though it was ridiculous to talk about there being any opposition to this method of handling agricultural pests. However, the scientist needs but to start in the field and he will find that there is real live opposition to it.

The advance agent of the spray manufacturer at once sees that when scale insects are eliminated from the grove by natural means his sales of spraying machinery must necessarly be reduced. Consequently he makes it his business to repeat and re-repeat all the stories of failures and supposed failures. It is not unusual to find a layman who considers the introduction of fungus diseases a failure long before the infection has had time to kill off the first lot of insects that were infected, and long before the fungi have had time to fruit and make secondary or tertiary infection.

Along with the spraying-machine man comes also the manufacturer of insecticides and his agents. Their business is

necessarly interfered with as soon as the natural methods for the control of scale insects are advocated; and since the profits, especially on the proprietary brands of insecticides, are quite considerable, they naturally believe that handsome stories must be told to keep up the popularity of their particular brand.

Singularly enough, from a source entirely unexpected, opposition comes from old-line entomologists. For the most part these men have been trained in regions where climatic conditions are not favorable to the introduction and spread of fungus diseases of insects. The literature has been pretty thoroughly reviewed by them and studies made of the situation, their deductions being based on experiments and work done under conditions quite different from those occurring in Florida and to some extent along the rest of the Gulf Coast. These entomologists, as a rule, come into the field in a sceptical state of mine, if not indeed in a prejudiced one, and not infrequently miss the point altogether by their want of familiarity with the fungus side of their question.

Under the conditions it has been necessary for the experiment station, practically single-handed, to disseminate the information and to establish this method of handling scale insects and whitefly. Like all other methods of handling these pests it must be used with discretion and with knowledge. There are conditions under which the method will succeed only indifferently and where the artificial methods of control should be used.

Dominant and Recessive Characters in Barley and Oat Hybrids.

By R. W. Thatcher,
Washington Experiment Station.

The experiments in hybridizing cereals at the Washington State Experiment Station were begun in 1899 by Prof. W. J. Spillman, and have continued to be an important part of the station's work from that time to the present.

The earlier studies were all with wheat. They were undertaken originally for the purpose of obtaining a hardy winter wheat with a stiff straw and compact, non-shattering head, such as would be particularly adapted to the methods of harvesting in vogue in the large wheat-growing sections of the state. This primary object of the work was successfully attained, and in addition other and perhaps even more important results were secured. Professor Spillman was able to discover, early in the progress of the investigations, certain laws of combinations of characters which have been widely quoted and discussed, and have had a marked influence upon the progress of breeding investigations. As a quite unlooked-for result, several new varieties of wheat were secured which, in addition to the properties originally sought, exhibited very high yielding qualities.

After several years' trials in our experimental fields, these were distributed to farmers and are now very extensively grown in our own and adjoining states. Estimates for the past year's crop were that 400,000 acres of these Washington Station hybrid wheats were grown in the Pacific Northwest states this year, and that the average yield of these was at least five bushels per acre greater than that of the best yielding varieties commonly grown. It seems to be a conservative estimate that during the past four years the wheat yield of our state has been increased by a total of 5,000,000 bushels, as a result of the distribution of these hybrid wheats.

As a result of this strikingly successful outcome of Professor Spillman's original crosses of wheats, our station has gone very extensively into other crosses of wheat for other purposes, and into the hybridizing of other cereals. For a num-

ber of years, this work was in charge of investigators whose chief interest was in the practical outcome of each cross, rather than the scientific principles which might be determined by mathematical counts and percentages of the various types resulting from the different crosses. Some three years ago, however, the work was reorganized on a basis which should provide both for hybridizing and selection for practical improvement, and for study of the results obtained from the standpoint of the principles of breeding involved in the several crosses. A considerable mass of new information has been accumulated from the hybridization work with wheat, barley and oats. It is the purpose of this paper, however, to present only that which deals with the dominant and recessive characters found in some of our barley and oat hybrids. This work has been done chiefly by Mr. E. F. Gaines, the Assistant Cerealist of our experiment station, and his assistants, under more or less direct supervision and suggestion from myself.

BARLEY HYBRIDS.

A portion of the facts with reference to the dominant or recessive character of certain units in barley hybrids which are presented below, have already appeared in articles by von Tschermak,[1] and Biffen,[2] and in Bateson's recent book on "Mendel's Principles of Heredity." These publications appeared after our work was well under way, and it was deemed wise to continue our counts and other studies, for the purpose of confirming results obtained abroad and of including in the series some points not covered by European investigators. The following brief statements include, therefore, some points previously brought out by Biffen and von Tschermak, but are presented in order to give a comprehensive view of our work and results.

Barley—First cross, made in 1910.

Male parent, Washington No. 94, "Bald Barley," six-rowed, hooded, bald.

Female parent, Washington No. 92, "Beardless Barley," hooded, hulled.

F_1 generation, 10 plants grown in 1911, all six-rowed, hooded, and hulled, indicating dominance of hulled over bald character.

[1] Zeits. f. d. landw. Versuchsw. in Oesterr. 4 (1901), Heft 2.
[2] Jour. Agric. Sci., 2 (1907), p. 183.

TABLE I.—SPRING BARLEY. F_2 BALD × HULLED.

Row No.	Hulled.		Bald.		Total No. plants.
	No. plants.	Per cent.	No. plants.	Per cent.	
26501	308	74	111	26	419
26601	550	74	193	26	743
26701	551	75	181	25	732
26801	558	74	196	26	754
26901	113	75	37	25	150
27001	355	75	122	25	477
27101	105	72	40	28	145
27201	427	76	136	24	563
27301	76	71	32	29	108
27401	65	75	22	25	87
Total	3108		1070		4178
Average	....	74.4	....	25.6	....

The theoretical percentages for a single pair of unit characters in the F_2 generation are 75 per cent and 25 per cent of the dominant and recessive charcters, respectively. From the above table, it is clearly evident that the bald vs. hulled character is a unit character in which the hulled is dominant and the bald recessive.

Barley—Second cross, made in 1910.

Male parent, Washington No. 93, "Black Bald Barley," six-rowed, bearded, bald, weak-necked, black kernels.

Female parent, Washington No. 92, "Beardless Barley," six-rowed, hooded, hulled, strong-necked, white kernels.

F_1 generation, 13 plants were grown in 1911 from kernels successfully hybridized in this cross.

F_2 generation, all plants grown this year were separated into the following groups: Bearded and bald; bearded and hulled; hooded and bald; hooded and hulled. No separations which would take into account the strength of neck or color of kernels were attempted in this cross. The results of the counts are shown in Table II.

TABLE II.—SPRING BARLEY F_2. BEARDED AND BALD × HOODED AND HULLED.

Row No.	Hooded and hulled.		Hooded and bald.		Bearded and hulled.		Bearded and bald.		Total No. plants.
	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	
16401	241	58	79	20	61	15	33	8	414
16501	243	58	72	17	73	17	33	8	421
16601	266	56	78	16	95	20	35	7	474
16701	300	58	95	18	95	18	29	6	519
16801	93	47	53	27	31	16	19	10	196
16901	206	55	76	20	76	20	19	5	377
17001	166	54	61	19	63	20	19	7	309
17101	360	57	119	19	115	18	40	6	634
17201	230	56	85	20	69	17	25	7	409
17301	276	55	98	20	92	18	34	7	500
17401	98	58	33	20	30	18	8	4	169
17501	278	59	74	16	89	19	29	6	470
Total	2757	.....	923	.....	889	.....	323	.....	4892
Average	......	56.3	......	18.9	......	18.2	......	6.6	......

The theoretical distribution of dominant and recessive characters in a cross involving two unit pairs is $56\frac{1}{4}$ per cent of the combined dominants, $18\frac{3}{4}$ per cent of each of the combinations of one dominant with one recessive, and $6\frac{1}{4}$ per cent of the combined recessives. The percentages in the table prove conclusively that the beared vs. hooded is a unit pair in which the hooded character is dominant and the bearded recessive. The same relationship between the bald and hulled types as found in the first cross is also shown here.

Barley—Third cross, made in 1910.

Male parent, Washington No. 90, "Bald Barley," beaded bald, two-rowed (having four rows of sterile beardless spikelets).

Female parent, Washington No. 92, "Beardless Barley," hooded, hulled, six-rowed.

F_1 generation, 10 plants from this cross were grown in 1911.

F_2 generation. Separations and counts made only on basis of bearded vs. hooded, and two vs. six-rowed characters.

TABLE III.—SPRING BARLEY, F_2. TWO-ROWED AND BEARDED × SIX-ROWED AND HOODED.

Row No.	Two-rowed and hooded.		Two-rowed and bearded.		Six-rowed and hooded.		Six-rowed and bearded.		Total No. plants.
	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	
24901	156	48	66	21	78	24	23	7	323
25001	157	44	82	23	91	26	25	7	355
25101	114	52	46	21	42	20	16	7	218
25201	142	51	65	23	57	20	17	6	281
25301	128	45	70	24	65	23	23	8	286
25401	141	54	47	18	60	23	14	5	262
25501	192	52	78	21	82	22	17	5	369
25601	135	45	54	18	87	29	22	8	298
25701	173	47	73	20	106	28	18	5	370
25801	128	45	58	21	78	20	18	6	282
Total	1466	.....	639	.....	746	.....	193	.....	3044
Average	......	48.2	......	21.0	......	23.5	......	6.3	......

Here again the dominance of the hooded type over the bearded type is clearly shown. The figures also show that the two-rowed and six-rowed character is a unit pair in which the two-rowed type is dominant and the six-rowed recessive. The percentage distribution of the combined dominant and the dominant-recessive combinations is not exactly according to the mathematical theory of combinations; but this is easily explained by the difficulty of segregating some of the hybrid types into their proper classes, the exact line of demarcation between hooded and bearded and two- and six-rowed types in these hybrid forms being extremely difficult to determine, many of them carrying abortive beards and partially filled kernels in their median spikelets. Bateson quotes Biffen to the effect that three distinct types result from a cross of two-rowed on six-rowed barley. In our counts on this particular cross, the intervening or hybrid type was not counted separately, but included in the type into which its dominant character would naturally throw it.

Barley—Fourth cross, made in 1910.

Male parent, Washington No. 131, "Rice Barley," two-rowed, bearded, hulled, arrowhead spike.

Female parent, Washington No. 92, "Beardless Barley," six-rowed, hooded, hulled, long, cylindrical spike.

F_1 generation, 6 plants from the cross, grown in 1911.

F_2 generation. The plants were first separated into bearded vs. hooded types, and these each afterward separated into two-rowed, hybrid, and six-rowed types, the hybrid types being those which bore beards or hoods upon their median spikelets, but whose lateral spikelets were partly or all fertile and had no beards or hoods. As shown in Table IV, an irregularity developed in this cross, in that nearly 20 per cent of these plants proved to be winter type barleys, *i. e.*, did not head out at all during the season. These have been saved over for later study.

The percentages of proportionate distribution of the various groups, when computed on the basis of spring types, show clearly the dominance of hooded over bearded, and of two-rowed over six-rowed, characters as noted in preceding crosses. The distribution of two-rowed, hybrid, and six-rowed types in both the hooded and bearded classes, showing the characteristic 1–2–1 Mendelian ratio and the 26.6 per cent bearded types as compared with 73.4 per cent hooded types, furnishes confirmatory evidence that this is a unit pair character.

TABLE IV.—SPRING BARLEY, F_2. TWO-ROWED AND BEARDED × SIX-ROWED AND HOODED.

Row No.	Winter type.		Bearded types.						Hooded types.						Total No. plants.
			Six-rowed.		Hybrid.		Two-rowed.		Six-rowed.		Hybrid.		Two-rowed.		
	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	
28801	205	21	36	4	126	13	65	7	132	13	259	27	154	16	977
28901	82	22	14	4	27	7	22	6	60	16	92	24	80	21	377
29001	91	17	30	6	48	9	24	5	44	8	152	29	142	27	531
29101	90	17	36	7	67	13	21	4	52	10	195	37	72	14	533
29201	101	17	31	5	52	9	21	4	66	11	216	37	95	16	582
29301	120	19	43	7	73	11	46	7	67	10	209	32	91	14	649
Total	689	......	190	....	393	......	199	......	421	......	1123	......	634	......	3649
Average	......	18.9	....	5.2	....	10.8	....	5.4	....	11.5	....	30.8	....	17.4	....
Average of spring types				6.4	....	13.5	....	6.7	....	14.2	....	37.8	....	21.4	....
Average of bearded vs. hooded types						26.6						73.4			

SUMMARY. BARLEY HYBRIDS. F_2 GENERATION.

Table I—Bald × Hulled.

Total No. Plants	4178
Hulled	3108 = 74.4%
Bald	1070 = 25.6%

Table II.—Bearded, bald × Hooded, hulled.

Total No. Plants	4890
Hooded and hulled	2757 = 56.3%
Hooded and bald	923 = 18.9%
Bearded and hulled	889 = 18.2%
Bearded and bald	323 = 6.%

Table III.—Two-rowed, bearded × Six-rowed, hooded.

Total No. Plants	3044
Two-rowed, hooded	1466 = 48.2%
Two-rowed, bearded	639 = 21.0%
Six-rowed, hooded	746 = 23.5%
Six-rowed, bearded	193 = 6.3%

Table IV.—Two-rowed, bearded × Six-rowed, hooded.

Total No. Plants	3649
Total No. Spring Type Plants	2960
Bearded, two-rowed	199 = 6.7%
Bearded, hybrid	393 = 13.5%
Bearded, six-rowed	190 = 6.4%
Hooded, two-rowed	634 = 21.4%
Hooded, hybrid	1123 = 37.8%
Hooded, six-rowed	421 = 14.2%
All bearded types	782 = 26.6%
All hooded types	2178 = 73.4%

OAT HYBRIDS.

Our hybridization work with oats has two principal practical objects; viz., to secure a white-hulled, early maturing, heavy yielding oats, and to attempt to fix the hull-less character upon some of our best native oats. Some difficulty was encountered at first in making successful cross-pollinations, and a careful study was made of the conditions under which the largest proportion of successful artificial fertilization could be obtained. These results are now ready for publication, but would be out of place in this paper.

Prior to the preparation of this paper, we were unable to discover in the available literature any reference to investigations of Mendelian characters in oat hybrids. All hybridizing

work with oats thus far reported seemed to have as its purpose the securing of some immediate practical result in increased yield or other desirable qualities, rather than a study of the unit characters involved. The last Experiment Station Record to arrive, however, contains an abstract of a report of the wheat and oat breeding work at the Svalof Station. This contains some conclusions concerning the side and tree type of panicle, to which reference will be made in connection with some of our observations below.

Oats.—First series—Color of hull and type of panicle.

First cross, made in 1910.

Male parent, "Black oats," black kernels, side type of panicle, late maturing.

Female parent, "Sixty-day oats," white kernel, tree type of panicle, early maturing.

F_1 generation, nine plants were grown in 1911.

F_2 generation, see Table V.

Second cross, made in 1910.

Male parent, "Black oats," same as before.

Female parent, "Palouse Wonder," white kernels, tree type of panicle, medium early maturing.

F_1 generation, five plants were grown in 1911.

F_2 generation, see Table V.

Third cross, made in 1910.

Male parent, "Black oats," same as before.

Female parent, "Regenerated Swedish Select," white kernels, tree type of panicle, late maturing.

F_1 generation, three plants were grown in 1911.

F_2 generation, see Table V.

Fourth cross, made in 1910.

Male parent, "Black Tartarian oats," very similar to "Black oats" above, with slightly denser panicle.

Female parent, "Regenerated Swedish Select," same as before.

F_1 generation, two plants grown in 1911.

F_2 generation, see Table V.

Fifth cross, made in 1910.

Same varieties as fourth cross but crossed in reverse direction.

F_1 generation, two plants grown in 1911, precisely similar in appearance to the F_1 of preceding cross.

F_2 generation, see Table V.

TABLE V.—OATS, F_2. BLACK AND SIDE PANICLE × WHITE AND TREE PANICLE.

Cross and Row No.	Black and tree.		Black and side.		White and tree.		White and side.		Total No. plants.
	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	
Black×Sixty-day:									
12201	291	64	69	15	63	14	32	7	455
12301	647	62	125	12	226	22	44	4	1042
12401	877	68	108	8	276	21	42	3	1303
12501	236	66	44	12	65	18	15	4	360
12601	193	66	42	14	52	18	6	2	293
12701	372	66	68	12	114	20	12	2	566
12801	78	60	19	15	28	21	5	4	130
12901	10	59	2	12	4	23	1	6	17
13201	19	59	6	19	4	13	3	9	32
Total	2723	......	483	......	832	......	160	......	4198
Average	......	64.9	......	11.5	......	19.8	......	3.8	......
Black×Palouse Wonder:									
14701	581	74	32	4	160	21	8	1	781
14801	468	71	32	5	152	23	3	1	655
14901	332	73	18	4	97	21	10	2	457
15101	524	73	27	4	156	22	9	1	716
15201	361	73	21	4	106	21	10	2	498
Total	2266	......	130	......	671	......	40	......	3107
Average	......	72.9	......	4.2	......	21.6	......	1.3	......
Black and Regenerated Swedish Select:									
11901	518	66	83	10	155	20	34	4	790
12001	146	67	25	12	41	19	5	2	217
12101	67	71	6	6	21	22	1	1	95
Black Tartarian×Regenerated Swedish Select:									
11701	10	67	2	13	3	20	0	0	15
11801	16	53	4	13	5	17	5	17	30
Regenerated Swedish Select×Black Tartarian:									
11501	75	40	52	27	33	17	30	16	190
11601	116	54	46	22	43	20	9	4	214
Totals—all crosses	5937	......	831	......	1804	......	288	......	8860
Averages—all crosses	......	67.0	......	9 3	......	20.4	......	3.3	......

The counts for each plant of each of the five crosses given in the above table show conclusively that the black hull is dominate over the white hull, and that the tree, or whorl, type of panicle is dominant over the side type of panicle. The average percentage distribution of black and white types in each cross and the same average for all crosses is uniformly quite close to the theoretical 3 to 1 ration, proving conclusively that this is a unit pair of charcters.

The distribution as between side and tree types of panicles, however, is very irregular, varying from 8 per cent to 57 per cent of side panicled plants in different individual strains, with an average for all plants and crosses of 87.4 per cent tree types and 12.6 per cent side types. This indicates that this particular character is probably not a unit pair, and is in harmony with the observations of Nillson-Ehle, which have appeared in print since the preparation of this paper was commenced. Dr. Nillson-Ehle suggests that instead of being a unit pair, this habit of tree or side growth of panicles is really the result of combinations of two unit pairs of characters, which are associated with the presence or absence of ligules and of the side or tree type of panicle, these latter being concomitant. Our observations were not made in such a way as to permit an expression of opinion as to the ability of this assumption of Nillson-Ehle to explain the variable results recorded in the above table.

Oats—Second series—color and persistence of hulls.

Sixth cross, made in 1910.

Male parent, "Palouse Wonder," same as before.

Female parent, "Chinese Hullless," both floral glume and palæ large and loose, and non-persistent, so that kernels thresh free of hulls, floral glume white, palæ black, kernel white, tree type of panicle, elongated central rachilla in spikelets, giving compound appearance to spikes.

F_1 generation, seven plants grown in 1911.

F_2 generation. Black kernels appeared in large numbers in this generation, indicating that there must have been some recessive black strain in the ancestry of

one or both the parents used in this cross. It was difficult to separate the different types in this generation, as many individual plants were found (doubtless hybrid types), which showed two or more different types of grain in the same panicle, a phenomenon which we have never observed to occur in any other hybrid cereal. In the counts of this cross presented in Table VI, all plants showing both hulled and hullless kernels in the same panicle were classed as "hullless" and all plants bearing both black and white kernels as "black."

Seventh cross, made in 1910.

Male parent, "Chinese Hullless," same as before.

Female parent, "Black oats," same as before.

F_1 generation, two plants of this cross were grown in 1911.

F_2 generation. It has thus far been possible to make counts of the different types from only two of the rows of grain from this cross. (See Table VI.) In making these counts, all plants bearing both hulled and hullless grains were classed as "hybrid." A curious result found here is that there were no plants bearing black, hullless grains. This same phenomenon was observed in the preceding cross, but in making these counts, the hybrid types were classed as "hullless," thus making it appear that some black, hullless plants were found.

Eighth cross, made in 1910.

Male parent, "Regenerated Swedish Select."

Female parent, "Chinese Hullless."

F_1 generation, only one kernel was successfully pollinated in making this cross, from which one plant was grown in 1911.

F_2 generation. All kernels from this cross were white. The plants were therefore separated on the basis of hulled and hullless character only, and gave the following counts: hulled, 180 plants (23%); hybrid, 394 plants (51%); hullless, 203 plants (26%); total number of plants, 777.

TABLE VI.—OATS, F_2. BLACK HULLED AND WHITE HULLED × CHINESE HULLLESS.

Cross and Row No.	Black types.*						White types.*						Total No. plants.
	Hulled.		Hybrid.		Bald.		Hulled.		Hybrid.		Bald.		
	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	No. plants.	Per cent.	
Palouse Wonder × Chinese Hullless:													
10001	347	44	(†)	.....	104	13	118	15	(†)	.....	214	28	783
10101	298	54	.....	.....	75	14	72	13	.....	.....	104	19	549
10201	260	32	.....	.....	204	25	79	10	.....	.....	269	33	812
10401	0	0	.....	.....	0	0	101	42	.....	.....	137	58	238
10501	28	20	.....	.....	43	31	13	9	.....	.....	55	40	139
10601	110	24	.....	.....	10	24	23	5	.....	.....	217	47	360
10701	22	48	.....	.....	14	30	3	7	.....	.....	7	15	46
Total for white cross	1065	.....	.....	.....	450	.....	409	.....	.....	.....	1003	.....	2927
Average for white cross	.....	36.4	.....	.....	.....	15.4	.....	13.9	.....	.....	.....	34.3	.....
Black × Chinese Hullless:													
15301	22	17	63	50	none.	.....	8	6	17	14	16	13	126
15501	68	25	115	42	none.	.....	20	7	26	10	42	15	271
Total for black × white cross	90	.....	178	.....	0	.....	28	.....	43	.....	58	.....	397
Average for black × white cross	.....	22.6	.....	44.8	.....	0	.....	7.0	.....	10.8	.....	14.6	.....

*Plants bearing both black and white kernels were counted as black in both crosses.

†Plants bearing both hulled and hullless kernels were counted as hullless in this cross.

It is difficult, if not impossible, to draw any definite conclusions from the results so far obtained from the crosses in which "Chinese Hullless" is one of the parents. The appearance of black kernels in the progeny from a cross of two white-kernelled parents indicates heterozygotism in one or both parent strains, which, however, does not seem to have a consistent effect in the various crosses. Perhaps later and more extensive counts than have been possible since the 1912 harvest may throw more light on the problem.

In one of the crosses there is evidence of a Mendelian ratio between the hulled and hullless character, but in others such a proportional distribution is wholly lacking. It will require further investigation, therefore, to afford conclusive evidence on this point.

SUMMARY. OAT HYBRID. F_2 GENERATION.

Table V. Black, side × White, tree; five different crosses.

Total No. Plants	8860
Black, tree	5937 = 67.0%
White, tree	1804 = 20.4%
Black, side	831 = 9.3%
White, side	288 = 3.3%

Table VI. (*a*) *White, hulled*[1] × *Chinese hullless* (*white.*)

Total No. Plants	2927
Black, hulled	1065 = 36.4%
Black, hullless	450 = 15.4%
White, hulled	409 = 13.9%
White, hullless	1003 = 34.3%

(*b*) *Black, hulled × Chinese hullless* (*white.*)

Total No. Plants	397
Black, hulled	90 = 22.6%
Black, hybrid	178 = 44.8%
Black hullless	0 = 0 %
White, hulled	28 = 7.0%
White, hybrid	43 = 10.8%
White, hullless	58 = 14.6%

(*c*) *White, hulled*[2] × *Chinese hullless.*

Total No. Plants	777
Hulled	180 = 23%
Hybrid	394 = 51%
Hullless	203 = 26%

[1] Palouse Wonder. [2] Regenerated Swedish Select.

Two Important Western Poisonous Plants.

By H. G. Knight,
Wyoming Experiment Station.

During the past several years thousands of sheep have died in Wyoming through what was supposed to have been the eating of poisonous plants on the ranges. For the seasons 1907 to 1909, the losses occurred in many instances in localities where the areas grazed were somewhat circumscribed, and in several of these places a certain plant that later came to be suspected as poisonous was found in enormous numbers. Several different species of plants have at times been suspected by stockmen, and until very recently the private opinion of those who have raised stock was the only evidence upon which one could base a conclusion as to the nature of the trouble.

The importance of this problem to the stockmen of Wyoming and of other states in the west can hardly be overestimated. Some idea of the values involved may be gained by considering the estimates made by owners in the business, and on this basis the losses reached the high average of 14.6 per cent. In terms of the last assessment valuation of sheep in Wyoming, this means an annual loss of more than $3,000,000. Sheep men who have followed the business for the past ten years estimate that of the total losses noticed, 60 to 70 per cent have been caused by poisonous plants and the remainder by coyotes.

The attention of the Wyoming Agricultural Experiment Station was first definitely directed to this question by calls for investigations at Casper, Medicin Bow, and several other places during the seasons of 1907–8. It was thought at first that the losses were due to a disease commonly known as "grub in the head." The idea that the losses were due to poisonous plants seemed to be favored indirectly, however, by the results of two veterinarians of the Bureau of Animal Industry who made studies during the aforesaid season and who made careful search for animal parasites.

WOODY ASTER.

These facts, and a trip made by the station botanist and veterinarian to various sections, caused a plant commonly known as woody aster (*Zylorrhiza Parryi Gray*) to be suspected. This plant was very abundant in those areas designated by the sheep men as "poison patches." Preliminary experiments were conducted which proved conclusively that woody aster should be classed as a poisonous plant. It appears to be confined to the arid and semi-arid region, and in soils in which only the so-called alkali-enduring vegetation will thrive. The most abundant species in Wyoming is the *Parryi*, which does not, however, occur over the entire state, but is restricted to certain districts, characterized by what is known as the adobe or gumbo type of soil, intermixed somewhat with gravel and containing larger or smaller quantities of the salts commonly designated as alkali. A consideration of further interest in this connection is that this particlar plant is not only confined to the type of soil name, but that Wyoming is the center of its distribution.

The investigation of the poisonous properties presented several difficulties. To start with, the aster is almost invariably more or less infected with a fungus, and in the season of 1910, during which the sheep losses in Wyoming from suspected poisoning were fewer than in either of the previous years mentioned, this aster was quite free from fungus in sections investigated. Among other species of the genus *Zylorrhiza* of which three or four have been described, only the *villosa*, so far as I am aware, has been known to be infected with this fungus, and no other has been suspected of having poisonous properties. It should be stated in this connection, however, that extracts made from portions of the aster practically free from this fungus were shown to be poisonous, from which it followed that the aster and the fungus would have to be investigated separately. The investigation of the fungus has not been carried out at the Wyoming Experiment Station thus far. Finally, one must not lose sight of the fact that a treatment of a case of poisoning from this source is often impossible because of the rapidity of the action of the active constituents. The poison in woody aster is often so active

that sheep men have estimated that more than ninety per cent of the animals affected die.

Some time during the middle of June the plant usually dries up because of the dry weather, becoming yellowish-brown in color. Shortly after this sheep begin eating the aster freely, showing that when withered it becomes not only more palatable but inactive.

In beginning the work upon the woody aster, field experiments were conducted upon sheep to determine its poisonous properties; also laboratory work upon extracts made with different solvents and a plant analysis was made. I shall not take the time to give the approximate analysis. It is sufficient to say that the plant has rather a high food value and the ash is rather high, which is usual with alkaline-resisting plants. A large amount of sand is present in the ash of the root, probably blown in. A spectroscopic determination was made for barium with negative results. The analysis of the ash did not reveal the presence of toxic salts. We have been working in the chemical laboratories of the Wyoming Experiment Station for over two years now, attempting to extract the toxic principles from woody aster. We have not as yet succeeded. At last report, a few days ago, extracts with straight alcohol and acidulated alcohol apparently removed alkaloids; at least a test for alkaloids could be obtained with Meyer's reagent, but when this was made alkaline, even with the most mild alkaline agencies, pyridine was given off. Probably the alkaloid belongs to the pyridine groups and decomposes exceedingly readily, so that further and probably more difficult work must be done.

The symptoms of woody aster poisoning as determined by feeding the plant and extracts where a number of sheep have been killed under the eye of experts are as follows:

There is a weakness of locomotory muscles with prostration; later the weakness extends to the muscles of the neck. Temperature rises very rapidly from 103 to 104.5°. Pulse very rapid and weak, from 92 to 300. Respiration is labored, with mucous rales. Bloat is generally pronounced. Severe abdominal pains evidenced by groaning. Increased secretion of the urine is noted. Froth, often bloody, from the air passages. Mucous membranes vary from bloody to bluish.

The feces are soft, with mucous, to very soft. The pupils are sometimes noticeably dilated. Cerebral symptoms are present in a few instances. Before death complete prostration and apparent unconsciousness occur. The course varies from three hours to three or four days, according to the amount of plant ingested and its condition. In looking for suspected cases of woody aster poisoning, the bloody froth from the air passages and bloat are considered conclusive evidence.

The autopsies give the following general results:

Practically all the organs are congested and inflamed.

Fermentation in the rumen, producing a frothy mass with a small amount of flatus. Slight inflammation, in the omasum with some shedding of the epithelium of the folds or leaves Inflammation of the intestines, colon and rectum. Passive. congestion of the liver and a cloudy swelling with death. Spleen congested. Pancreas slight congested. Lymph glands congested. Apparently an albuminoid degeneration of the kidneys. Bladder generally full, with some inflammation. Lungs badly congested, with dropsical swelling and inflammation. Trachea and air passages injected. Fluid in the heart sac, with inflammation of the heart muscles. Brain occasionally slightly injected. Peritoneum in effusion.

At present no treatment has been determined which is satisfactory, and the only safe method apparently, is to avoid the aster patches. This is not difficult to do, as even the most ignorant can tell the aster patches long distances away. Tapping has not been productive of good results, although some relief has been reported by the escape of the gas. Stimulants and anti-ferments have produced some relief; morphine appears to give results in cases not too badly affected.

DEATH CAMAS.

The poisonous character of the several species of plant designated as death camas has long been known to the stockmen of our western states. These plants belong to the genus *Zygadenus*, and are found in Montana, Wyoming, Colorado, and other states in the northwest, where they have from time to time caused heavy stock losses, particularly among sheep. Chestnut and Wilcox, in an extensive survey of stock

poisoning plants, state that during the season of 1900, 3070 cases of sheep poisoning by Zygadenus came under their immediate observation, and that probably only about one-fourth of the actual cases were brought to their attention. Of this total, 651 cases proved fatal. According to their observations, only one other stock-poisoning plant, lapine, is more destructive to the sheep than Zygadenus. In Wyoming probably this latter statement does not hold true.

In this state the most common species in the *Z. intermedius*, and the greatest stock losses noted have usually occurred in the early spring when this plant is in bloom, and before the early forage plants are plentiful. The idea prevails that poisoning is more frequent immediately after rainstorms, and it has been suggested that this might be accounted for on the general knowledge that in some plants the active constituent is found chiefly in the roots and that when the ground is moist and soft the bulbous portion could be more easily uprooted by cattle and sheep. Such a view, however, is scarcely supported by our experiments, for analyses show that the bulb and the leaves differ but little in the amount of alkaloid contained. The flower contains a higher percentage of alkaloid than any other part of the plant. In the light of these facts, the more probable explanation of the greater frequency of poisoning immediately after rainstorms would seem to be that at such a period either the flowers are more numerous, or the animal eats a greater quantity of leaves than usual. A possible explanation of the tendency to eat such a plant at all when anything else is available may be found in the fact that the plant as a whole has a relatively high food value, while the bulb, which is doubtless eaten to some extent, contains a high percentage of sugar.

In their Report of a Study of the Stock-Poisoning Plants of Montana, Chestnut and Wilcox described feeding and other experimental tests with extracts of *Zygadenus venenosus*. In a preliminary chemical study of the constituents of the same species, Slade obtained, by means of color tests, evidence which led him to conclude that the poisonous character of the plant was due to the presence of the alkaloids sabadine, sabadinine and veratralbine. Another report of work by Reed Hunt gives some reason for suspecting that the effect

of the plant is due to an alkaloidal mixture very closely resembling veratrine.

Thus the subject of the toxicity of this plant was in a rather confused state and offered an interesting field for further investigation. Our work has been confined to the species available in Wyoming, which was identified as *Zygadenus intermedius* by Prof. A. Nelson of the Wyoming station. This species is a near relative of the better known *Zygadenus venenosus.* It is also known as poison camas, lobelia, squirrel food, wild onion, poison sago, poison sago-lily, mystery grass, etc.

Analysis of the plant indicated a high food value. The analysis of the ash revealed no toxic salts. Following preliminary assay for the presence of alkaloid in different portions of the plant, three methods were tried for determining the percentage of alkaloids present. The first method was the official method of the United States Pharmacoepia for the assay of belladona leaves, which was modified to the extent of using ether instead of chloroform in the final extraction. The second method was the above modified to the extent of using Prolius solution instead of the ether-chloroform mixture as a menstruum. The third method was to extract as far as possible with 95 per cent alcohol, and concentrate under reduced pressure to a volume of 200 c.c. The last method could not be used for the bulb because of the presence of quantities of sugar. The alkaloid found in the leaves, bulb, flower and root was as follows:

	Method 1.		Method 2.		Method 3.
	I.	II.	I.	II.	
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Leaf	0.665	0.629	0.612	....	0.570
Bulb	0.188	0.211	0.565	0.570	....
Flower	1.07	1.35	....	....	....
Root	.306	.329	....	....	....

It will be noted that the alkaloid is most abundant in the flowers, which contain approximately 1.25 per cent. It was at first thought to be sabadine from its physiological action and from its reaction with chemical reagents. The alkaloid was then prepared in quantity. I shall not take the time

to go into the detail of this work. Suffice it to say that the alkaloid crystallized from a hot super-saturated solution of ether. The first crop melted at 193° C. and weighed about 5.6 grams. Finally, impure crystals were recrystallized from 95 per cent alcohol, whereupon the alkaloid separated into orthorhombic crystals containing alcohol of crystallizations, in which condition it is much less soluble than in the anhydrous state. A portion melting at 193° was also subjected to extensive fractional crystallization from benzene, from which was obtained a varnish in one fraction, and apparently a pure alkaloid melting at from 200° to 201°, to a red oil in another, crystallizing in radiating clusters of shining needles from benzene. Subjecting the alkaloid to analysis, the following results were obtained as an average of eight determinations: Carbon, 66.44 per cent; hydrogen, 8.92 per cent; nitrogen, 2.27 per cent; oxygen, 22.37 per cent.

Molecular weight determinations by the boiling point methods in alcohol give 693 as a probable molecular weight. More work will be done upon this. Calculating out by formula, we get C_{39}, H_{63}, NO_{10}. Molecular weight calculated from this formula would be 704.506. The product is evidently a new alkaloid and has been named zygadedine. It resembles ceradine in many ways.

Properties of the Alkaloid.—Crystallizes in beautiful orthorhombic blocks from absolute alcohol with two molecules of alcohol of crystallization. An acid solution of the alkaloid yields a voluminous precipitate with Meyers reagent, and a beautiful aurichlorate is formed when to the hydrochloric-acid solution of the base an acid solution of aurichloric is added. This salt is soluble in hot water and crystallizes in elongated dense prisms upon cooling. This salt has not yet been analyzed.

The specific notation is 42.8 degrees. The pure alkaloid has not been tried upon sheep to determine its physiological action, but has been tried with guinea-pigs, frogs and dogs. The fatal dose for guinea-pigs appears to be between 4.6 and 5.1 mg. for 100 grams of the animals when injected subcutaneously. Whether injected subcutaneously or interperitoneally or after feeding, the alkaloid produces the same symptoms of poisoning.

In general, experiments with small animals lead to the following conclusions:

The alkaloidal preparation slows the heart rate by action apparently on the cardial inhibitory center; it slows respiration by an effect involving the respiratory centers; it causes vasco dilation. In quantities approaching a fatal dose it hastens the heart rate and produces both irregularity of the heart beat and convulsive respiration. The fatal dose given intravenously to dogs stops the heart before respiration ceases. It has a very powerful action, whether injected or fed, both as a purgative and as an emetic. Up to the present time an antidote has not been obtained.

In closing, I might say that the work which we have been carrying on has proved to be of great economic value. At one shipping point and shearing pens in Wyoming, the annual losses for three years aggregated $30,000 per annum. After work had been started upon the woody aster and our expert had been in the field making field tests, this was cut down until last year the loss was almost negligible, although the plants grew in the neighborhood as profusely as in former years. In talking with sheep herders, we found that they were keeping away from the aster patches, and in no case did I find in a band of sheep aggregating 2,000 over six or seven deaths due to this plant. The work on the death camas is too recent to show any economic results, and probably will not unless we determine an antidote, as it is rather difficult to identify on the range by the layman and does not confine itself to definite types of soil recognizable by location. It may be found in any of the high valleys and even on the plains.

Investigations on Soil Fertility in Texas.

By G. S. Fraps,
Texas Experiment Station.

The Texas Experiment Station has been for a number of years investigating the factors of fertility, particularly with reference to Texas soils. The factors considered relate chiefly to phosphoric acid, potash and nitrogen. Other factors are so intimately connected with these factors that they must also be considered in the solution of the problems. The work has been carried on by means of chemical investigation in the laboratory, by means of pot experiments, and to some extent by means of cooperative field experiments in different parts of the State.

The object of the chemical investigation is to ascertain the significance of the plant food extracted from the soil by various solvents, so to secure information as to the condition of the plant food in the soil. The solvent studied has chiefly been fifth-normal nitric acid, and the phosphoric acid or potash dissolved has been termed *active* phosphoric acid or potash. But stronger acids and other solvents, such as ammonia, have also been taken into consideration. Partial results of these investigations have been published in Bulletins 126, 136, 145 and 151 of the Texas Experiment Station. These deal chiefly with the phosphoric acid and potash of the soil.

Study of various mineral phosphates shows that phosphates of lime are dissolved almost completely by fifth-normal nitric acid in the quantity ordinarily found in the soil, while the basic phosphates of iron and alumina are only slightly soluble in this solvent. There is, however, some phosphoric acid dissolved from iron and aluminum phosphates. We estimate that approximately 20 parts of phosphoric acid per million of soil comes from the phosphates of iron and aluminum, while that in excess of this quantity comes from the phosphates of lime.

The phosphoric acid extracted by the solvent does not necessarily represent the phosphoric which is accessible to plants. On the one hand, the phosphate of lime may be

distributed through particles of carbonate of lime which are dissolved by the solvent, but not exposed to plant roots. On the other hand, the soil has a fixing action upon phosphoric acid even in acid solution, which reduces the amount of phosphoric acid which is extracted by the solvent from the soil. That is to say, the phosphoric acid in the soil extract does not necessarly mean the entire amount of phosphoric acid dissolved from the soil, but is a resultant of the solvent and fixative forces. The amount of fixation depends upon the character of the soil. There are some soils rich in iron and aluminum oxides which hold back the dissolved phosphoric acid to as much as 90 to 95 per cent. This fact has been ascertained by estimation of the quantity of phosphoric acid extracted from the original soil and from the same soil to which a known quantity of phosphoric acid has been added.

The results are somewhat different in the case of potash. Potash is fixed to a less extent from solution than is phosphoric acid. Potash fixed by soil minerals is not completely extracted by the solvent. The various potash silicates examined are not so sharply defined in solubility as were the phosphates. Some of the potash-bearing silicates are largely dissolved by the solvent, but they are not completely dissolved. The feldspars give up a small portion of their potash to the solvent. The chemical work with the potash minerals leads to the conclusion that the solvent does not make a sharp distinction between the easily dissolved potash and that highly insoluble. It extracts a large portion of the easily dissolved potash, but at the same time it leaves behind an appreciable portion of potash in this form. The potash dissolved in excess of approximately 50 parts per million comes from the more easily soluble potash minerals. The potash below 50 parts per million may come from the less soluble silicates, such as felspar, which apparently have little value to plants.

The analysis of the soil with the fifth-normal nitric acid, therefore, enables us to ascertain approximately the quantity of phosphate present as phosphates of lime, and the quantity of potash in the more easily soluble silicates. It does not follow that soils of different origin and character, which contain the same chemically soluble plant food, will also behave

the same to plants. The plant food is not necessarily present in the same compounds. Their value to plants will depend upon their condition in the soil and also upon various factors which modify their availability. It is quite possible that conditions of moisture, temperature, the presence of organic matter, and perhaps various minerals, will exert a decided modifying action upon effect of the different forms of phosphoric acid and potash in the soil upon crop growth. These facts must be carefully considered in discussing the results of soil analysis. It is also possible that there may be forms of phosphoric acid in the soil which are active but which are not soluble in the fifth-normal nitric acid.

The chief objects of the pot experiments are to ascertain the relation of the chemical composition of the soil to the growth of the plant, and to study the effects of different factors upon the value to the plant of different minerals containing phosphoric acid and potash. Results of some pots experiments are published in Bulletins No. 126, 145 and 151 of the Texas Experiment Station. These experiments have been extensive rather than intensive. The soils used come from widely separated parts of Texas, but as a rule they have never been fertilized.

As a result of these experiments, it has been clearly shown that the average results of the pot experiments are closely related to the active phosphoric acid, the active potash, and the total nitrogen of the soil. There are, of course, individual exceptions. Soils containing less than 20 parts per million of active phosphoric acid (extracted by fifth-normal nitric acid) are highly deficient in phosphoric acid for pot experiments. Soils which contain 20 to 100 parts per million of phosphoric acid are usually deficient in pot experiments, and the extent of their deficiency is related to the quantity of phosphoric acid present. The effect of the addition of potash to the soil upon the average weight of the crop in the pot experiment decreases with the quantity of potash in the soil soluble in fifth-normal nitric acid. The average percentage of potash contained in 235 crops increases as the quantity of active potash in the soil increases. The effect of fertilizer nitrogen in 332 pot experiments decreases as the percentage of nitrogen in the soil increases.

Pot experiments are not exact methods of chemical analysis and are subject to influence from other factors than those being studied. In conducting such experiments it is necessary not only to ascertain the total crop produced, both with the complete fertilizer and with the fertilizer less the plant food being studied, but also to determine the composition of the crop and ascertain the quantity of the plant food taken up. This is especially important in the case of potash and nitrogen, as the amount of these taken from the soil may increase decidedly without a corresponding increase in the crop. Thus, in our experiments the percentage of potash in the crop increases as the amount of active potash in the soil increases. After the active potash ceases to have an effect upon plant growth, it still continues to have an effcet upon the quantity of potash taken up. The relation of the plant food taken up by the crop to the composition of the soil is shown in the following tables. Instead of stating the result in terms of phosphoric acid, nitrogen and potash, however, we state them in terms of bushels of corn per acre which could be produced by the quantity concerned, allowing for both grain and straw. The result, therefore, enables us to judge of the relative deficiency of the soil in plant food.

TABLE 1.—RELATION OF ACTIVE PHOSPHORIC ACID OF SOIL TO PHOSPHORIC ACID REMOVED BY THE CROP.

Parts per million active phosphoric acid in soils.	Average corn possibility in bush. per acre.
0. —10	4.5
10.1—20	12.5
20.1—40	20.0
40.1—100	24.3
100.1—190	52.5
310. —420	60.7

TABLE 2.—RELATION OF ACTIVE POTASH OF SOIL TO POTASH REMOVED BY THE CROP.

Parts per million active potash in soil.	Average corn possibility in bush. per acre.
0— 50	58.6
50—100	74.4
100—150	102.0
150—200	161.8
200—300	240.2
300—400	313.8
400—600	238.8
600—800	413.8

TABLE 3.—RELATION OF TOTAL NITROGEN OF THE SOIL TO NITROGEN REMOVED BY THE CROP.

Percentage of nitrogen in soil.	Average corn possibility in bush. per acre.
0.—.02	8
.021—.04	12
.041—.06	18
.061—.16	30
.161—.18	56

These figures represent the average results of several hundred pot experiments. Some of the experiments were conducted under relatively unfavorable conditions. If all of the experiments had been under favorable conditions the averages would no doubt be higher. In times past it has been the custom to speak of a soil as deficient or not deficient in a certain plant food, and there is a difference of opinion as to where this deficiency begins.

Using the tables given above we can express the relative deficiency of a soil in concrete terms. For example, if a soil contains 10 parts per million of active phosphoric acid, 120 parts per million of active potash, and .08 per cent of nitrogen, we can say that its corn possibility in pot experiments is about 8 bushels for phosphoric acid, about 102 bushels for potash, and about 25 bushels for nitrogen. This soil would be, therefore, relatively most deficient in phosphoric acid, next in nitrogen, and least in potash, in the pot experiment. When we are able to apply these results to the field it may be possible to calculate the quantity of phosphoric acid and of nitrogen which should be added in sufficient quantities to bring mean production up to the lower limit of some other controlling factor, as the rainfall. This, however, is a matter for the future. But this method of investigation does give us the means of comparing the relative deficiency of soils by means of chemical analysis and by pot experiments.

It must be remembered that the conditions which surround pot experiments are different from those in the field. The pot experiments are conducted under relatively more favorable conditions. The temperature is higher, we have an abundant supply of moisture, the plants are protected from insects and storms, and there is a larger proportion of growth of plant to the quantity of soil. Therefore, in the pot experi-

ment the draft upon the soil will be much larger than it is in the field. It is quite possible for a soil to appear deficient in the pot experiment, when it would not be deficient in the particular element under field conditions. That is to say, the quantity of plant food which could be withdrawn under field conditions might be vastly less than the quantity which could be taken up in the pot experiment.

We feel safe in saying, now, that there is a relation between the chemical composition of the soil and its needs in pot experiments. The relation must be worked out in detail, and applied to field conditions. Various types of soil may have somewhat different relations in their reaction of plant needs to pot experiments. The relation of the type to the need should be worked out. The other factors than plant food must be studied and valued. Our present work gives a basis for the tentative valuation of phosphoric acid, nitrogen and potash, in terms of crop yields in pot experiments. It is a step in advance.

Distribution of Humus in California Soils.

By R. H. Loughridge,
California Experiment Station.

It has been known for many years, to those who have given the subject any thought, that the soils of California possess special features that distinguish them from those of the more humid region of the United States, and which require also different methods of cultural treatment. For instance, it is well known that they have not the subsoils found in the humid region which are marked by a loss of the dark humus color at from 6 to 9 inches below the surface, and by the presence of a raw or unproductive subsoil layer at a depth of one or more feet. The heavier soils of California as found in the valleys show, as a rule, a dark humus tint to fully 36 inches.

It was also long ago shown by hundreds of analyses, given in the California Station reports, that because of the arid climatic conditions, California soils are richer in the elements of plant food than those of the humid region. Thus the averages of more than 600 analyses from each of the two regions show that there is about three times more of potash, nearly ten times more of lime and one-fourth more of phosphoric acid in the arid than in the humid soils. In more recent investigations we have found that this richness in California soils is not confined to the upper few feet, but extends downward almost indefinitely. In fact, the depth of California soils is limited only by country rock or water, and occasionally by a cemented gravel hardpan, known locally as bedrock.

It is also well known that because of these favorable conditions of good texture, abundant plant food, air and moisture at great depths in California soils, the roots of all plants and trees have penetrated downward to a surprising extent. Not only are the roots of orchard trees found at from 15 to 30 feet or more below the surface, but those of wheat, barley and ordinary weeds have been traced to as much as 13 feet in the clay loam soil of the University Farm at Davis, and in the black, heavy clay soils of the hillsides at Berkeley.

But still another feature is now to be added to the above, for it is even more characteristic of arid lands; viz, the distribution of humus downward to depths of many feet, not alone in alluvial bottom lands, but in the upland valleys and bench lands as well as in the higher hill lands. This feature was first ascertained in 1904 in my examination of the fifteen soil columns, each of 12 feet depth, procured by me for the state and experiment station exhibit at the St. Louis Exposition. In several of these columns the humus was found in each of the twelve feet. Soon afterward I began a more extended examination of the soils of the state, and as rapidly as circumstances would permit have during the past few years secured columns of typical soils from the agricultural regions, to ascertain whether or not this downward distribution of humus was of common occurrence throughout the state, as well as through the arid region generally.

We have now a collection of more than 100 soil columns varying in depth from 8 to 12 feet each, placed on exhibition in upright cases, the soil of each foot being in a sixteen-ounce bottle and properly labeled. This collection well shows the difference in character of the many soil regions of the state, the changes in color, and in texture, from the surface soil down through the twelfth foot; it forms a highly attractive and instructive exhibit, and we believe is the only one of its kind anywhere.

Physical analysis of the first foot of each column, chemical analyses of the first, sixth and lowest foot, respectively, and humus determinations of each foot, have been in progress for some time in our laboratory. Prof. C. B. Lipman of the California Station has also made bacteriological examinations of carefully taken columns from several localities, the results of which have been published by him in scientific journals. They show that the important soil bacteria reach in these soils to far greater depths than has heretofore been observed or supposed. The determinations of humus in the soil columns have been nearly completed, and the results will, we hope, soon appear in bulletin form. In the mean time a summary of the investigation may be of interest to the Society.

It should be understood that in this paper the term *humus* is applied to those substances eliminated from soils by the

Grandeau process of extraction. I have not undertaken to differentiate between the various ingredients known to result from humification of vegetable and animal matter under the usual soil conditions.

We found that the humus in 62 of the columns was distributed through the entire 12 feet, in some cases reaching several feet deeper; in many others it was limited by water or bedrock at 8 or 10 feet below the surface. In but few instances did we fail to find it at the bottom of the soil column. The amount of humus is greatest in the upper 3 feet, and frequently more in the second than in the first foot; thence it gradually diminishes downward, with an occasional and sometimes large increase even in the lower depths. Whether such increase is due to exceptional development of roots in soil layers specially favorable to such development or to an accumulation of former surface vegetation, subsequently buried, is a concrete question for each particular case and not always easy to decide.

The percentages in the first foot vary from a maximum of 4.6 per cent in an upland soil to less than 0.2 per cent in some desert lands and also in some of our strong alkali soils. The general average of the first foot of each of the 100 columns is 1.25 and of the twelfth foot .26 per cent. This is a little more than the average heretofore reached in the analyses of 678 surface soils of the arid region, and is about one-fourth of the general average of humus found in the examination of 600 soils of the humid region of the United States.

When grouped according to agricultural regions, we find that the valleys of the Coast Range of mountains in the western part of the state are richer in humus than any other region, and that they surpass even the alluvial lands of the streams. There is a general average of more than 1 per cent in the upper 3 feet, and nearly 0.5 per cent in the twelfth foot. The lands of the foothills of the Sierra Nevada on the eastern side of the state rank next to the Coast Range in humus content, but are not as deep, being underlaid at from 4 to 8 feet by slate and other rock strata. The lands of the Sacramento valley and of southern California are nearly alike in humus content, while those of the San Joaquin valley are much below them. The desert soils and those having much alkali

are very low in humus, though the humus is here also distributed through many feet in depth.

The percentage of nitrogen has been determined in the humus of nearly all of the soils, and has been found to vary from 2 per cent to as much as 20 per cent in exceptional cases. There is a very uniform percentage of from 4 to 6 per cent, the general average of the 100 columns being 5.5 per cent. In the majority of cases the nitrogen is greater in the second foot than in the first, as is to be expected as the result of oxidation in the dry, hot summers, and by long cultivation without replenishment.

It is extremely fortunate that this is the case, for the humus and the splendid texture of the soil column combine to hold sufficient moisture from the winter rains to carry crops far toward maturity in the dry, rainless summers.

It has heretofore been thought that in respect to humus content the soils of the arid west are inferior to those of the humid east, but this investigation reveals the fact that in reality there is more humus in California soils than is found in those of the uplands of the humid regions; and although not concentrated in the first foot as under humid conditions, it occurs where it is of greatest benefit to the roots of plants which have their chief development in the second and third foot, away from the heated and dry surface soil. It is very true that these surface soils in California do need more humus, but this is chiefly to improve physical conditions and to overcome any tendency to bake or crust over.

This distribution of humus downward through many feet is then a very valuable and prominent characteristic of not only the alluvial but all upland soils in California.

Observations on Soil Inoculation.

By Jacob G. Lipman,
New Jersey Experiment Station.

There is evidently some relation between different species of legume bacteria and soil reaction. It is common knowledge that soils too acid for the successful growing of alfalfa may produce fair crops of clover. Moreover, there are legumes that will apparently prefer soils possessing a distinct acid reaction.

Lupines and serradella, extensively grown in Germany, are a case in point. I may also cite in this connection an experience of our own. Several years ago, we were conducting a series of investigations on the value of commercial cultures for soil inoculation. One of the tests dealt with alfalfa, grown on plots, some of which had received an application of ground limestone, at the rate of 2 tons per acre. The other plots on which the alfalfa was grown received no applications of lime, and in fact had not been limed to our knowledge for at least thirty years. Aside from the difference in reaction brought about by the application of lime on some of the plots, but not on the others, the treatment was exactly the same. The tillage operations, fertilization and inoculation were alike. A satisfactory stand of alfalfa was obtained on both the limed and unlimed plots. It was soon noticed however, that on the unlimed area the alfalfa plants were light in color and stunted in growth. Gradually, red top and sorrel made their appearance, and crowded out the alfalfa.

In the season following the seeding but few alfalfa plants could be found on the unlimed plots. To my surprise, however, I discovered that white clover had appeared spontaneously on this acid land and was rapidly spreading on a portion of the plots. This experience has, therefore, led me to conclude that white clover will grow on land too acid for alfalfa. Since nodules were present in abundance on the clover plants, I was further forced to conclude that the species, or at least varieties of bacteria, infecting clover will

develop in a medium too acid for the development of the species or varieties infecting alfalfa. Carrying out this process of reasoning further, it seems proper to assume that the micro-organisms must be capable of adapting themselves to a fairly wide range of soil reaction.

That this assumption is not unwarranted, is borne out by the knowledge common to all of us, that soy beans, cow peas, vetches, sweet clover, lima beans, field peas and many other legumes, will grow on all sorts of soils and evidently on soils possessing a more or less distinct degree of acidity.

RELATION TO SOIL NITROGEN.

Alfalfa, clover and other legumes, growing in very rich garden soil, are now and then found to possess no root nodules. Similarly, root nodules are often found wanting on legumes growing in soils naturally poor in organic matter and nitrogen, but which have recently received a heavy application of nitrate, or of other readily available nitrogen compounds. For instance, in our own experiments we have been able to suppress nodule formation on cow peas by the application of nitrate of soda at the rate of 300 to 400 pounds per acre.

The facts in the case may be readily explained by the apparent ability of the legumes to resist infection whenever the supply of avalable nitrogen compounds in the soil is at all adequate for the normal development of the plants. When this supply ceases to be adequate, the so-called hunger period arrives and the weakened plants are unable then to keep out the invading bacteria.

Under field conditions, the store of nitrogen compounds in the soil is seldom, if ever, adequate for making the legumes independent of *Bacillus radicicola*. Infection is found to occur rather early in the growing period of the host plant. In the more open, sandy soils not too poor in organic matter, infection is likely to occur more readily than in the heavier soils. Not infrequently, the lighter soils are not well enough supplied with vegetable matter to permit the survival of these bacteria in large numbers, but if even a few of these bacteria be present, they will in time cause more or less thorough inoculation even in the poorer sandy soils.

I have observed, time and again, inoculated areas in alfalfa fields. Within these areas, the plants were dark green in color and vigorous in appearance. Outside of them, the plants were smaller and lighter in color. Slowly, but steadily, the edges of these infected areas moved outward and it was possible for us to measure from day to day the spread of the infection. In a few weeks the plants in the entire field assumed the healthy green characteristic of properly inoculated alfalfa. It was evident in this case that when a few alfalfa bacteria are present in the soil, and if conditions for their multiplication be favorable, they are bound to increase in numbers and cause the infection of all of the plants in the field. It seems to me further, that the legume bacteria are capable of growing and of multiplying in the soil itself. In support of this statement, I will relate the following experience.

Several years ago we grew Ito San soy beans on a soil area recently reclaimed from a state of neglect, covering a period of many years. Of course soy beans had never been raised on this land. After plowing in the spring, ground limestone was applied at the rate of 2 tons per acre, and acid phosphate and muriate of potash at the rate of 400 and 200 pounds per acre, respectively. The soy beans were planted in rows without inoculation. A good stand was obtained and careful cultivation was given to the crop. At the end of the growing season all of the plants were carefully pulled up and their roots were examined. Out of the hundreds of plants thus examined, single nodules were found on scarcely more than a dozen. In the following year, soy beans were again planted on this land without further inoculation. Seed from the uninoculated plants grown the year before was employed, hence no additional infection was made through the seed used. It was found, nevertheless, that the soy beans raised in the second season on land not originally inoculated, and from seed apparently free from bacteria capable of causing the formation of root nodules on these plants, were yet abundantly inoculated. Few of the plants in the second season contained less than 15 or 20 nodules, and some contained 50 nodules or more. I can account in no better way for the facts in the case than by suggesting that the very few bacteria introduced in the first season on the seed had been able

to increase in numbers in the soil itself. It is possible, further, that the native varieties of *B. radicicola* originally present in soil may have become sufficiently modified, in a few instances, to be able to enter into and develop in the roots of the soy beans. In either case, there is ample justification for the belief that *B. radicicola* may find the soil a suitable medium, not only for its survival, but for its increase in large numbers.

In more recent inoculation experiments on soy beans, we have found that the plants on the check plots, devoid of nodules had a much better root development than the plants well equipped with nodules. It happened that the experiments in question were conducted on heavy soils, well supplied with phosphoric acid and potash; hence the inoculated soy beans obtaining an abundant quantity of nitrogen from the atmosphere had no occasion to send their roots into the deeper layers of the soil. On the other hand, the uninoculated plants had to forage thoroughly in the surface soil as well as in the subsoil that they might find a more ample supply of combined nitrogen.

RATE OF SPONTANEOUS INOCULATION.

The rate of spontaneous inoculation varies with the texture of the soil, its reaction and its content of moisture and organic matter. We must assume, perforce, that the micro-organisms are carried from plant to plant by capillary water, even though it is not at all likely that the motile cells move in all directions from any infected spot. The texture of the soil directly affects the rate of rise of capillary water, and, therefore, also the rate at which soil bacteria are carried from place to place. More abundant precipitation, hastening the movement of soil water, will also hasten the spread of infection. Similarly, a favorable soil reaction established by applications of lime or wood ashes, and a more or less abundant supply of readily decomposable vegetable matter, will make possible a rapid multiplication of the micro-organisms and their ready spread through the soil. Because of the varying conditions just noted, the rate of spontaneous infection will vary from soil to soil, and from season to season. At times the infected spots will spread outward at the rate

of a few inches a day, and at times even more rapidly. New spots of infection at some distance from the older spots may appear in the field.

RELATION TO TEMPERATURE.

Uninoculated plants are more likely to be winter killed than inoculated plants. This observation holds good particularly in the case of alfalfa, winter vetch, and certain of the clovers. The winter-killing of alfalfa is more likely to occur in poor soil. When the land contains a fair store of nitrates at time of seeding, in the late summer, the plants will usually develop to an extent sufficient to enable them to withstand severe winter weather. When infection occurs early in the growth of the crop, and is reasonably thorough, the alfalfa plants usually make enough growth before the beginning of cold weather to enable them to pass through the winter safely. When the soil itself is poor in available nitrogen compounds, and when there is some uncertainty as to the thoroughness of infection, small quantities of nitrate may be used with profitable results. The nitrate will in this case act as a substitute for inoculation, permitting the plants to withstand the rigors of winter. Everything being equal, infection occurs more readily in warm weather than in colder weather. Alfalfa sown between August 10 and 15 will be more readily and thoroughly inoculated than alfalfa sown after September 1. This fact is seldom considered in the growing of alfalfa or other fall grown legumes, but it nevertheless deserves serious attention.

THE NEED OF INOCULATION.

The need of inoculation is not as apparent in the richer soils as it is in the poorer soils. Land containing much available nitrogen may not show the need of inoculation at all, since legumes new to that land will tend to become inoculated gradually, and the combined nitrogen in the soil will supply the wants of the crop until the inoculation is established. It remains true, nevertheless, that in the case of alfalfa and soy beans the use of inoculating material is nearly always essential in the establishment of these crops on land new to them. In case of vetch, cow peas, clover, etc., the beneficial

results secured from the use of the inoculating material are not so striking, but even here the use of inoculating material is often justified. In our experience, cow peas have failed to grow satisfactorily on some of our soils without inoculation. We have a number of reports from South Jersey to the effect that winter vetch does not do well on the lighter soils for a year or two. The Canada field peas, now grown at the College Farm, do much better than they did years ago when first introduced.

In a word, then, the need of inoculation is more general than it is commonly believed to be, and is noted and met only under the more extreme conditions, such as prevail in the growing of alfalfa, soy beans, lupines and serradella. About four years ago, we raised a crop of oats and Canada field peas on an old, neglected field that was very weedy and badly in need of liming. A fairly good crop was secured and the Canada field peas, when examined, were found to be well inoculated. After the removal of the oats and Canada field peas, the field was disked, harrowed and cow-pea seed was broadcasted on the land thus prepared. A good stand of cow peas was secured, but the plants were yellow and did not develop any nodules. A number of plants of the Canada field pea, and a number of plants of a wild vetchling common in this territory, found growing among the cow peas, were pulled up and were found to possess a large number of nodules on their roots. Evidently, no cross inoculation occurred between the cow peas, Canada field peas and the vetchling in question. We failed to find in other instances lack of cross inoculation between cow peas and soy beans or between red clover and alfalfa.

As to the value of inoculating material, particularly of the artificial cultures for thorough inoculation of soils already provided with the corresponding bacteria, the question is an open one. Reports are not wanting of tests that have given positive returns from such artificial cultures on land already well inoculated. In one of our cooperative experiments, we found that one of the commercial cultures gave better results than legume soil; in other experiments, on the other hand, soil has been found to be a more satisfactory inoculating material than artificial cultures. It is not at all impos-

sible or even improbable that artificial cultures will be sufficiently improved to justify their use on land already inoculated, but further research is needed for the definite solution of this problem.

METHODS OF INOCULATION.

As I stated a moment ago, legume soil seems to be in most cases a more effective inoculating material than artificial cultures. In using legume soil for inoculating purposes, the material may be broadcasted and harrowed in, as is the common practice, or it may be drilled in rows, as has been done successfully by us in the planting of soy beans for seed. Occasionally an infusion is made of legume soil by mixing in a barrel or tub a quantity of such soil and an adequate amount of water; the infusion thus secured is used for moistening the seed. Also, in the case of artificial cultures, the bacteria may be brought in direct contact with the seed or an infusion may be made for moistening a quantity of soil, which, when partly dried, may be either broadcasted or drilled. It is claimed that the direct inoculation of the soil, rather than the seed, obviates possible injury to the bacteria by substances formed in the germinating seed. Some of our data seem to lend a measure of support to this claim.

Generally speaking, our observations on soil inoculation point clearly to the importance of so modifying the soil as to make it a fit culture medium for legume bacteria. The use of lime, of readily available mineral fertilizers and of green manures of animal manures, may be recommended from this standpoint. Beyond that, the lacking bacteria should be supplied. Spontaneous inoculation may come, and usually does come, but the process is slow and uncertain at best, and should not be depended on for assuring us profitable yields of new legumes.

Soil Types of South Carolina on Which Cotton is Grown and their Fertilizer Requirements.

By J. N. Harper, Director,
South Carolina Experiment Station.

Most of the soils of South Carolina have been formed from the decomposition of granite and kindred rocks. Granite decomposes into sandy soils of various degrees of fineness and into loams of various grades. The soils of South Carolina can be divided roughly into six divisions or soil regions. In each division they are fairly uniform in composition but different in mechanical make-up. These six regions include the piedmont, the sandhill, the red hill, the upper pine belt, the lower pine belt, and the coast. The piedmont region occupies the northwestern half of the State. There are numbers of soil types found in this region, the two prevailing being the gray sandy loam and the brown clay loam. The sandy loam overlies a red clay subsoil. This subsoil, however, contains considerable amounts of sand. The sandy loam soil responds exceptionally well to commercial fertilizers, resists drouth effectually, and is favorably suited to cotton, corn, cow peas, sweet potatoes, and a variety of other crops. The clay loam overlies a red clay subsoil. This type is more productive than the sandy loam variety of soil during a wet year, but does not withstand a drouth as well. The clay loam is especially adapted to cotton, corn and small grains.

The South Carolina Experiment Station is located in the piedmont region, on the gray sandy loam type classified by the Bureau of Soils as Cecil sandy loam. These soils analyze .06 per cent of nitrogen, .12 per cent potash soluble in HCl sp. gr. 1.115 and .06 per cent of phosphoric acid soluble in HCl sp. gr. 1.115 In the first six inches, there are about 1,300 pounds of nitrogen, 2,600 pounds of potash, and 1,300 pounds of phosphoric acid. We have conducted field tests with fertilizers for the past eight years, and every year an application of phosphorus in connection with nitrogen has more than doubled the yield of the check plots. The plots receiving only phosphorus made a net gain above check of

$6.86 per acre. Those plots that received only nitrogen made a net gain of $7.31 per acre above the check plots, and those that received phosphorus and nitrogen combined made a net gain of $18.55 per acre above the check plots. These increased yields extend from year to year, and are conclusive and convincing and show clearly that this type of soil is greatly deficient in nitrogen and phosphorus in available forms, and readily responds to the application of these two necessary elements of plant food.

Our experiment station has tested the relative value of acid phosphate in comparison with finely ground phosphate rock and basic slag, and in every case the acid phosphate has far out-yielded the floats and slag, and this too when used in conjunction with manure. Some farmers of South Carolina have been applying acid phosphate as a fertilizer for a number of years, and practically all of this phosphorus is still in the first twelve inches of the top soil, excepting that which has been removed by plants, and the amount that has been applied in most cases is much larger than that taken off by crops. There has, therefore, accumulated a considerable amount of phosphorus that will gradually become available for plants. In some sections of the state this accumulation has gone on until now acid phosphate does not respond as a fertilizer when applied to cotton.

Field tests are not the only methods of solving the fundamental principles of fertility. They are, however, the beacon lights that will point out the broad road that the farmer must travel. The farmer does not care whether the use of phosphates is to furnish plant food or to counteract poisons. He wants to know whether or not the use of these materials increases crop yields and to what extent. Acid phosphate not only greatly increases the amount of cotton produced, but it also hastens the maturity of the cotton. It should, therefore, be used liberally on all soils where cotton is slow in maturing. It is especially recommended for bottom lands and soils where the cotton is said to "run to stalk" or weed, and on such soils a heavy application of acid phosphate is most beneficial. In this connection we will state that the farmer can very often determine the element most essential in a fertilizer for his different soils by noting the manner of

growth of the cotton on his different soil types. If the growth is slow and the plants have a yellow, unhealthy look, applications of nitrogenous fertilizers will be most beneficial. If the plants look to be vigorous in their growth but are not fruiting, acid phosphate should be applied.

The piedmont soils are rich in potassium. A chemical analysis of these soils shows that they have an abundance of this element, but it is locked up in insoluble compounds and only a small amount becomes available each year. If these soils are kept in proper mechanical condition and a sufficient amount of organic matter is maintained in them, a sufficient supply of potash will become available for ordinary yields. However, it pays to use small amounts of potash salts for most crops even in the piedmont region.

Our experiments at Clemson College show that it pays at the present price of corn and cotton to use as much as 600 pounds of a complete fertilizer per acre on the piedmont soils. A greater amount does not give sufficient increase in yield to pay for its application. Our tests show that the economical fertilizer should be one analyzing 8 per cent phosphoric acid, 3 per cent nitrogen, and $2\frac{1}{2}$ per cent potash where cotton is constantly grown on the same land; and where a three-year rotation of cotton, followed by corn and cowpeas, followed by oats, followed by cowpeas, is practiced, it is not necessary to use a fertilizer analyzing but $1\frac{1}{2}$ per cent nitrogen.

The sandhill region extends diagonally across the State, through the central part. This soil belt is immediately below the old ocean line, which is south of the piedmont region. The soils are composed largely of white sand of various degrees of fineness, overlying a yellow sandy subsoil which extends to a considerable depth, in some places 20 feet. The total amount of phosphorus in some of these soils is as low as 300 pounds per acre in the first six inches. There is not a sufficient amount of phosphorus to produce forty crops of corn should this entire amount become available.

If crops are constantly grown and removed from the land, the elements of plant food in the course of time will become exhausted unless they are supplied in a fertilizer. It has been found that these sandy soils, while poor in plant food, respond readily to improved methods of farming. These

should be plowed as deep as possible, turning the fine subsoil to the surface, thus making the surface less sandy. They should be well supplied with green and stable manure, as they are very deficient in organic matter. When winter cover crops such as rye and vetch are turned under in the spring and a liberal application of commercial fertilizers is made, good crops are obtained. On this type of soil as much as $1\frac{1}{4}$ bales of cotton and 80 bushels of corn per acre has been produced economically.

The soils of the sandhill region are very deficient in potassium as well as the other elements of plant food, and potash must be used liberally to produce maximum crops. Five hundred to six hundred pounds of a fertilizer analyzing 8 per cent phosphoric acid, 3 per cent nitrogen and 5 per cent of potash will often give a 500 to 600 per cent increase in the yield of the crop.

The red hill region lies between the sandhill region and the upper pine belt. The type of soil embraced in this region occurs in scattered areas in a number of counties. The soils of this region when improved are the most productive in the State, and they respond most readily to the use of commercial fertilizers. The soils are brown to reddish-brown sandy loams, composed of fine to medium fine sand. This overlies in places a stiff red clay subsoil which varies from a light brown to a dark red color. This character of soil is the result of erosion, and is therefore quite variable in texture and in productive qualities. In some places the red subsoil is exposed over large areaas.

The soil of the red hill region is especially well adapted to cotton, and there are farms in this region that have been planted in cotton continuously for forty or more years, and are yielding to-day from 1 to $1\frac{1}{2}$ bales of cotton per acre whereas only a few years ago these same soils yielded only one-third of a bale per acre. This increased yield has been brought about mainly from the increased use of commercial fertilizers and the practice of turning under cotton stalks instead of burning them as previously. Cotton stalks that have made vigorous growth will add as much organic matter to the soil as a crop of clover. Of course this organic matter does not contain the rich nitrogenous compounds that are

found in clover, otherwise it is just as valuable. On some farms as much as 1,500 pounds of a complete fertilizer analyzing 7 per cent acid phosphate, $3\frac{1}{2}$ per cent nitrogen, and 4 per cent potash is used profitably. The winter legumes, such as crimson clover, bur clover and vetch grow exceptionally well on this type of soil.

The soils of the upper pine belt are comprised largely of the Orangeburg sandy loam type. This belt embraces some of the best agricultural counties of the south. The soils of this region are coarse to fine sandy loams. A yellow subsoil of fine silt and clay is found at a depth varying from 8 inches to 2 feet. This type of soil responds well to the application of commercial fertilizers, and there are in this region thousands of acres that produce a bale or more of cotton per acre. Cowpeas and soy beans grow most luxuriantly throughout this belt. In this belt it is necessary to use as much as 200 pounds of muriate of potash per acre on cotton to obtain the best results. Without this potash the plants do not mature their top fruit. Cooperative fertilizer tests conducted by our station show that in this soil belt as much as 1,000 pounds of a fertilizer analyzing 8 per cent phosphoric acid, 3 per cent of nitrogen and 5 per cent of potash is necessary to obtain maximum crops.

The lower pine belt extends entirely across the southern portion of the State, and lies adjacent to and immediately south of the upper pine belt. Some of the best soils of the State are within this region, but only a small percentage of the area is under cultivation. The greater part of the land is flat and in great need of drainage. The excessive amount of water in these soils is easily removed by underdrainage. The soils of the lower pine belt are well adapted to cotton, and to all kinds of vegetables and a variety of fruits such as pears and plums. The southern half of this region is devoted largely to the cultivation of cotton, corn, oats, sugar cane and cowpeas; and the northwestern half to cotton, corn and tobacco. In this soil belt is found one of the largest strawberry regions in the United States. In no part of the south will diversified farming prove more profitable. The soils of this region respond to the use of commercial fertilizers and in some sections as much as 1,500 pounds per acre are used

on cotton with profit. This fertilizer usually analyzes as much as 4 per cent of potash, 4 per cent of nitrogen, and 7 per cent of phosphoric acid.

The coast region is a narrow belt varying in width from 5 to 25 miles, extending entirely along the Atlantic border and including the Sea Islands. Most of the land of this region is greatly in need of drainage. The type of soil that is cultivated in cotton is a fine sandy loam of a light brown color, classified by the Bureau of Soils as Norfolk fine sandy loam. The sand particles composing this type are very small. The subsoil is of a light color and is composed largely of the same fine sand. The level depressions contain more silt and considerable organic matter. The soils of the marshes and swamps contain very little sand, but are composed largely of silt and clay. The fine sandy type is devoted largely to the raising of vegetables and the culture of Sea Island cotton. The silt soils are devoted largely to trucking. One of the largest cabbage districts of the country is found on this kind of soil. The Sea Islands are planted largely to cotton, yielding the finest and most costly fiber in the world.

This type of soil does not respond to heavy applications of acid phosphate, but is greatly in need of potassium. Experiments at our Summerville Station, which is located in this region, show that the application of potash salts is necessary to all crops. By the use of potash we were able to increase the yield of cotton in some cases as much as 25 per cent. The form of potash does not seem to influence the yield or the quality of cotton.

While potassium is most essential, the other elements of plant food are just as necessary as potassium, although not in as large percentages. Our tests show that a fertilizer analyzing 6 per cent phosphoric acid, 3 per cent ammonia and 5 per cent potassium is an economical fertilizer for cotton on the soils of this region. Stable manure when used in conjunction with acid phosphate on the piedmont soils and in conjunction with potash salts in the coastal region has always increased the yield of the crops far above all other plots treated with purely commercial fertilizers. In the piedmont region where 8 tons of manure per acre were used in connection with 352 pounds of acid phosphate, the net increase

above check has amounted to $25.32 per acre. This increased yield was due in a great measure to the improved physical condition of the soil and its water-holding capacity. While we are not in position to make any definite assertions along this line, we believe that the manure aids soil bacteria in accumulating nitrates in the soil. It will be many years, however, before the farmers of the south will have enough cattle to be able to put one ton of manure per acre on their soils. A system of farming can, however, be inaugurated and maintained that will insure large yields without the use of stable manure.

Almost every type of soil found in the State of South Carolina is deficient in calcium, and wherever lime has been used as a fertilizer good results have been obtained. The granite soils of the south are apt to become acid when green vegetation is incorporated with the soil. Lime on these soils greatly increases the bacterial flora of the soil. It also increases the growth of the leguminous crops, and we have data to show that it assists the legumes in accumulating nitrates in larger amounts in the soil. At our Coast Experiment Station, an application of 2,000 pounds of marl gave a 300 per cent increase in the yield of crops.

The controlling factor of plant food for practically all soils of South Carolina is nitrogen. There is not a sufficient amount of nitrogen in any of the soils of this State to produce maximum yields, therefore nitrogen must be a necessary constituent of all fertilizers for practically all crops. While the gain in the increase of crops by the use of nitrogen compounds is considerable, yet when this costly fertilizer is used in large amounts the increased yield is not commensurate with the additional expense, therefore every farmer should grow the leguminous crops more generally. The results of our station at Clemson and experiments made by others have shown that the soils of South Carolina are especially well adapted to most of the legumes, especially soy beans, cowpeas, bur clover, crimson clover, vetches, velvet beans, lespedeza, etc., and much of the money now spent for nitrogen could be saved if these legumes were grown in rotation. However, the growing of these legumes in a three-year rotation will not produce a sufficient amount of nitrogen for the production of maximum

yields of cotton, corn and the small grains. The farmer must therefore resort to the use of nitrogen in some commercial form, and he should insist that this nitrogen be in such a form that it will quickly become available. Our experiments show that the most available nitrogen is obtained from nitrate of soda, sulphate of ammonia, fish scrap, blood, cotton-seed meal, and tankage.

Practically all the soils of South Carolina will respond to good treatment and to fertilizers, and all of the cultivated lands of the State are of such a type that it pays to apply fertilizers in rather large amounts. The fields at our Coast Experiment Station when first plowed yielded about 12 bushels of corn per acre where no fertilizers were used, showing that the land was very deficient in plant food even in its virgin stage. When fertilizers analyzing 8 per cent phosphoric acid, $3\frac{1}{2}$ per cent nitrogen, and 4 per cent potash were applied at the rate of 1,000 pounds per acre, the increase in yield was phenomenal, the yield the third year of cultivation being 50 to 60 bushels of oats, 60 to 80 bushels of corn, and from 1 to $1\frac{1}{2}$ bales of cotton per acre.

South Carolina has greatly increased its agricultural production during the past ten years, and this increase has kept pace with the increased use of commercial fertilizers and better cultural methods. The farmers of South Carolina are now using far more fertilizers than the farmers of any other State of the Union, and this little State now produces about $160,000,000 of agricultural wealth annually, an increase of about $90,000,000 over ten years ago. The farmers of this State are now using from $15,000,000 to $20,000,000 worth of plant food. Many hundreds of thousands of dollars of this money, however, are lost through the inadvertence of farmers as to the fertilizer requirements of their various crops when grown on different soil types. Every soil type in the State should be fertilized with a different formula and every crop grown in different rotations should have varying percentages of phosphoric acid, potash and nitrogen. The farmers of South Carolina are beginning to understand the full value of plant food.

In the last few years a great many farmers have applied fertilizers in large amounts with the hope of producing large

yields of cotton. In some instances enough plant food has been used to produce from 2 to 3 bales of cotton per acre, yet the actual yield in some cases has not been more than 1 bale per acre. A shortage of water is very often the limiting factor. In fact, the most important soil problem in the south is the moisture problem. Few years the farmers get a sufficient amount of rain water to produce maximum crops, although the rainfall of this region will average about 50 inches per year. Therefore how best to manage his soil so as to retain a sufficient amount of water for crop growth is of great importance.

The soils of South Carolina are of such a texture that they will not hold more than 20 to 25 pounds of water per cubic foot. Some of these soils do not contain as much as .1 per cent of humus, and the average soils of the piedmont section will not contain more than .5 per cent The reason why most southern soils become unproductive is largely that the organic matter has been consumed, and this is due to the fact that they are of such a texture, being loose and porous, that oxidation takes place very rapidly. Humus is not a staple compound in southern soils but is ever changing in amount. Southern soils in their virgin state can be ever so fertile and yet become unproductive although no crop is planted, if they are kept constantly plowed for a period of years. While they are probably better suited to cotton than to almost any other crop, and cotton for a long time will be the money crop for this section of our country, yet if the farmers wish to make greater profits from its culture it will become necessary for them to rotate their crops more generally. Cotton is not an exhaustive crop when grown in rotation and when properly fertilized. The clean cultivation of it, however, augments the destruction of organic matter in the soil.

The piedmont soils of South Carolina 150 years ago were considered rich agricultural lands, but the farmers of that day did not pay any attention to maintaining soil fertility, and in due course of time great numbers of them moved from South Carolina to the western territories because the soil had been impoverished and washed away to such an extent that it was considered of little agricultural value. While most

of the farmers have learned how to protect their soils from washing by means of terracing and other methods, there are still to be seen in the piedmont section thousands of acres that have been so badly damaged by erosion that it will take years of efficient labor to improve them. There are many gullies where there were once gently sloping hillsides that produced splendid crops.

It is estimated that more than 80 per cent of the land of the piedmont section of the south has been greatly damaged by erosion. Most of the soils of South Carolina are of such a character that they will wash badly after the fibrous roots of the grasses have been destroyed by the clean cultivation of cotton. A light sandy or loam soil is very apt to suffer from washing. A single rain storm in the piedmont section often does great damage and washes away thousands of dollars' worth of valuable soil. Deeper plowing, proper methods of terracing, and the cultivation of crops that will produce fibrous roots, will in a great measure prevent this loss. Bermuda grass, the southern farmers' friend, if more generally grown, would reduce erosion to a minimum.

Probably the greatest lesson the farmers of South Carolina have yet to learn in maintaining soil fertility is the use of the winter cover crops. If they build up their soils to a high state of fertility by the use of legumes, commercial fertilizers, and barnyard manures, it will be necessary to have catch crops growing during winter and fall to prevent winter leaching. The best winter cover crops for this purpose are rye, oats, wheat, crimson clover, bur clover and vetch. All of these crops do well on southern soils, and they prevent the soil from washing during the heavy winter rains.

Relation of Meteorological Study to more Logical Systems of Cropping and to Crop Production.

By J. F. Voorhees,
U. S. Weather Bureau and Tennessee Experiment Station.

Meteorological records reveal the agricultural possibilities of a locality, and serve as a guide in planning an economical cropping system. Without a thorough knowledge of climate and of the growing habits of the various crops, the highest efficiency in production cannot be attained.

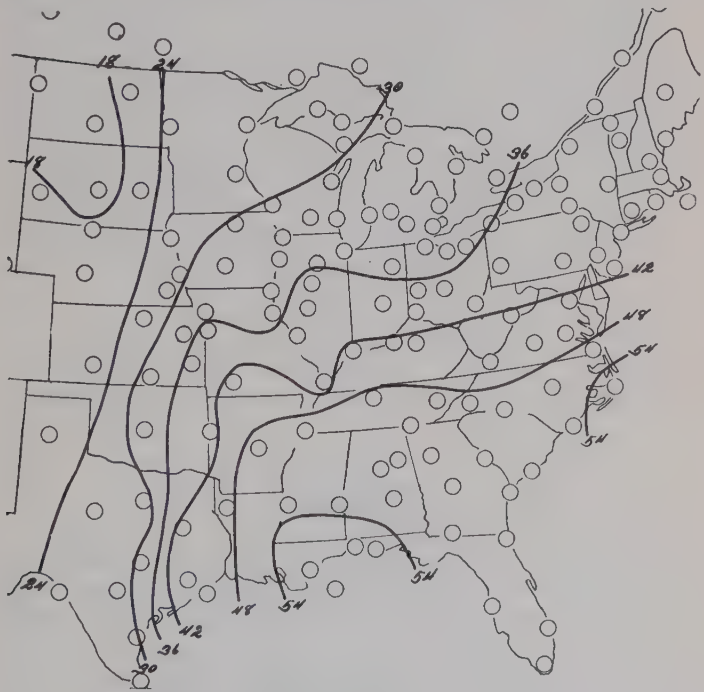
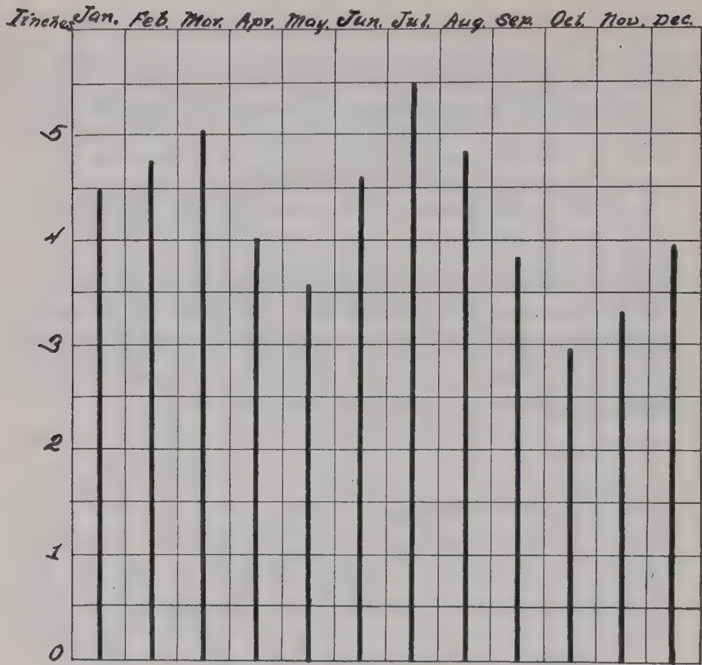
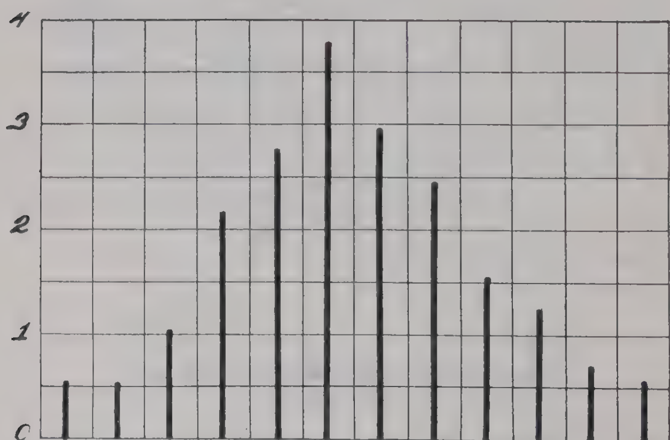


Chart 1.—Average Annual Rainfall.
(In inches.)

The necessary meteorological data for this country is being gathered by the Weather Bureau of the National Department of Agriculture and the most important facts have been



In the Southeast.



In the Dakotas.

Chart 2.—Average Monthly Rainfall.

published from time to time in bulletins of the Bureau, notably in Bulletin R, Daily Normal Temperature and Rainfall, and Bulletin V, Frost Data of the United States.

Using data from these bulletins, charts have been made to show the difference in climatic conditions in different parts of the country, and to point out the need of a cropping system

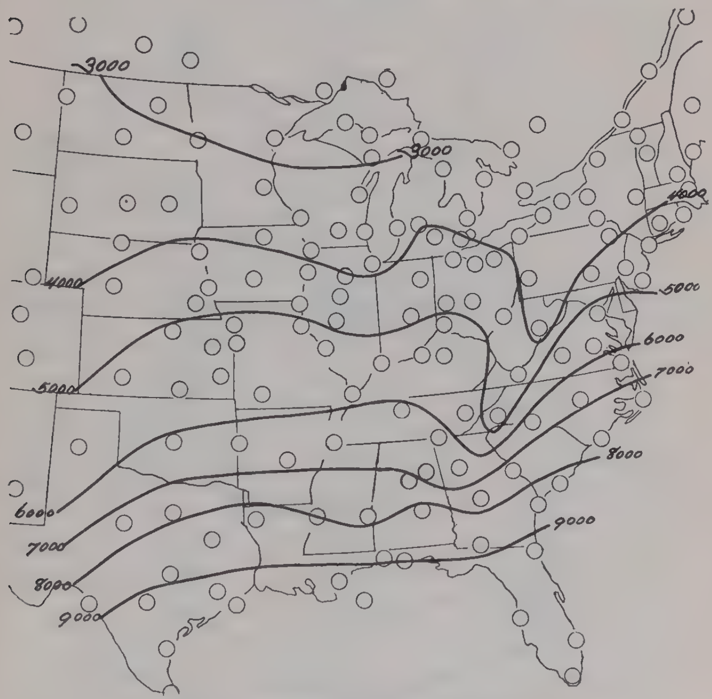


CHART 3.—ANNUAL EFFECTIVE HEAT.
(In degrees.)

in the southeast portion of the United States radically different from the system that is successful in the north and west.

Chart 1 shows the normal annual rainfall for the United States east of the 105th meridian. It will be seen at once that the states in the southeast receive in a year about three times as much rainfall as the states in the northwest portion of this region. This great difference fully justifies the assumption that a cropping system adapted to one of these regions would not be suitable for use in the other. To test the truth of this assumption chart 2 was made, showing the monthly

distribution of rainfall for these two localities. In the northwest we find a wet season in late spring and early summer, and a dry season extending from September to March. Thus the distribution as well as the amount of rainfall would limit the production of this region to one crop each year,

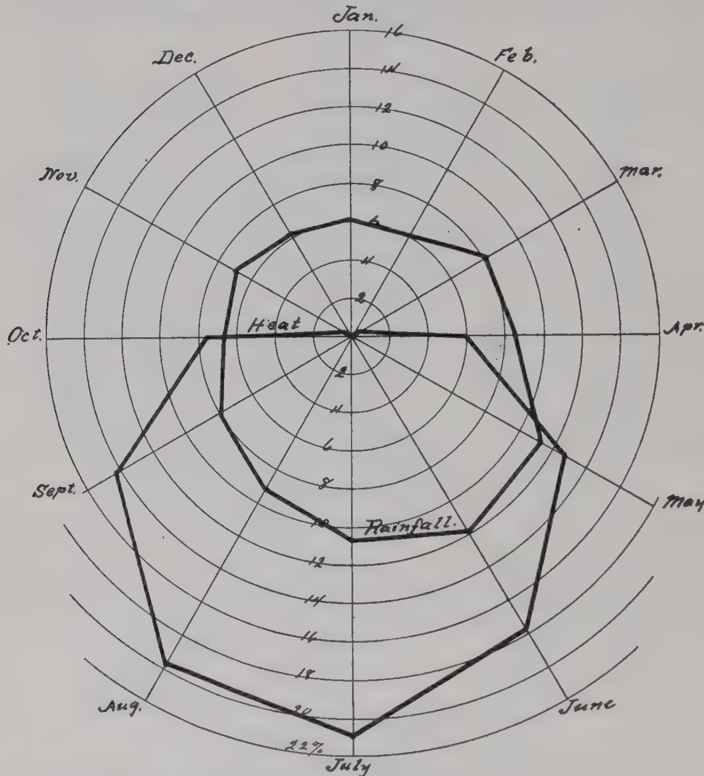


CHART 4.—MONTHLY PER CENT OF RAINFALL AND HEAT FOR THE FIVE STATES: OHIO, INDIANA, ILLINOIS, IOWA, AND MISSOURI.

Annual rainfall, 35.83 in.	Average effective heat, 4985°	Average growing season, 150 to 200 days.

regardless of what the temperature might be. In the southeastern states we have two wet seasons, one in winter and one in summer, separated by short, drier seasons in spring and fall. This distribution, together with the large amount of rainfall in this section, at once suggests a possibility of growing two crops each year if temperature conditions are favorable.

Chart 3 shows the average annual accumulated effective heat for the region east of the 105th meridian. We find that the southeast exceeds the northwest in effective heat as it did in rainfall, and in about the same proportion. There is evidently plenty of heat here to mature two crops each year,

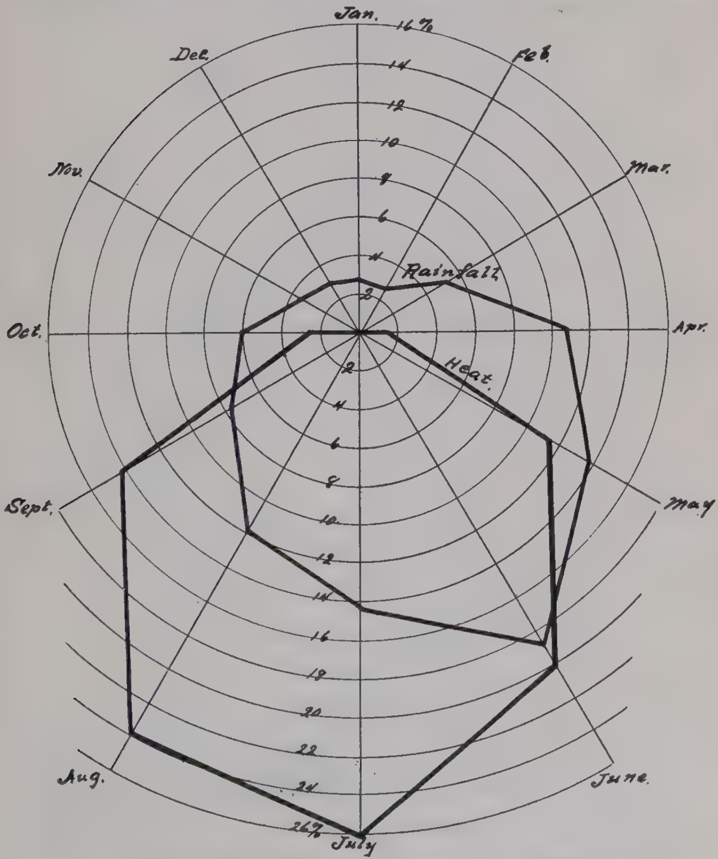


CHART 5.—MONTHLY PER CENT OF RAINFALL AND HEAT FOR THE DAKOTAS.

Annual rainfall, 20.37 in.	Average effective heat, 3160°.	Average growing season, 100 to 150 days.

and we have now to determine whether or not it is properly distributed. Charts 4, 5, 6, and 7 give the heat and rainfall distribution for four different sections of the country. In each chart there are two irregular closed curves. One represents the percentage of annual rainfall that is received each

month and the other the monthly per cent of the annual effective heat. Chart 4 represents the middle Mississippi and lower Ohio states, chart 5 the Dakotas, chart 6 central and northern Texas and Oklahoma, and chart 7 the six states Tennessee, the Carolinas, Mississippi, Alabama and Georgia.

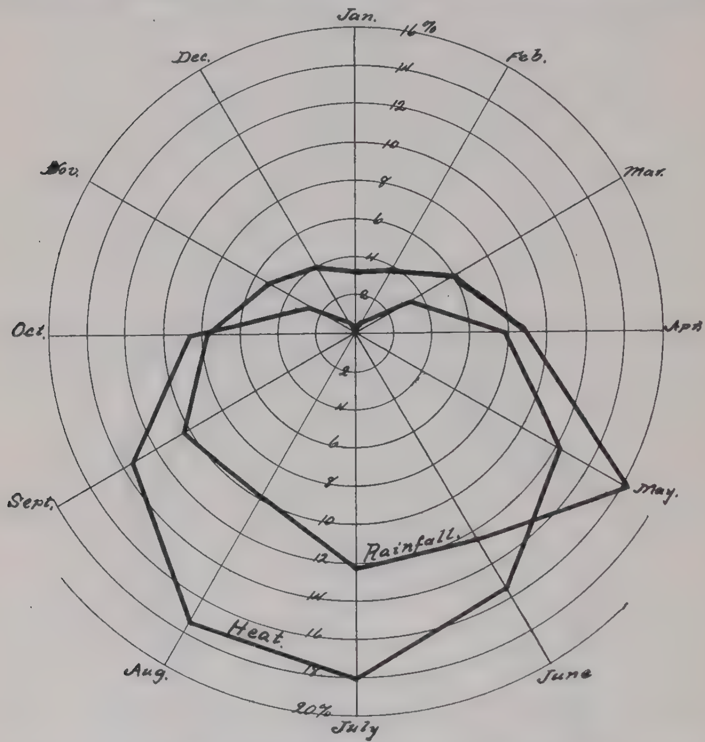


CHART 6.—MONTHLY PER CENT OF RAINFALL AND HEAT FOR CENTRAL AND NORTHERN TEXAS AND OKLAHOMA.

Annual rainfall, 26.22 in.	Average effective heat, 6340.°	Average growing season, 200 to 250 days.

It will be noted at once that three of these charts are very similar to one another. This means that any difference there may be between the climates of these three localities is in the quantity of heat and rainfall received and not in their distribution through the year. The increasing quantity of heat as we go southward does not mean that the days are hotter in the south but that the hot season is longer.

In this connection let us look for a moment at chart 8, which is a partial copy of chart 5 in Bulletin V of the Weather Bureau. This chart shows that the average growing season or the period between the last killing frost in spring and the first killing frost in the fall increases from 110 days on the Canadian border to 300 days or more on the gulf coast.

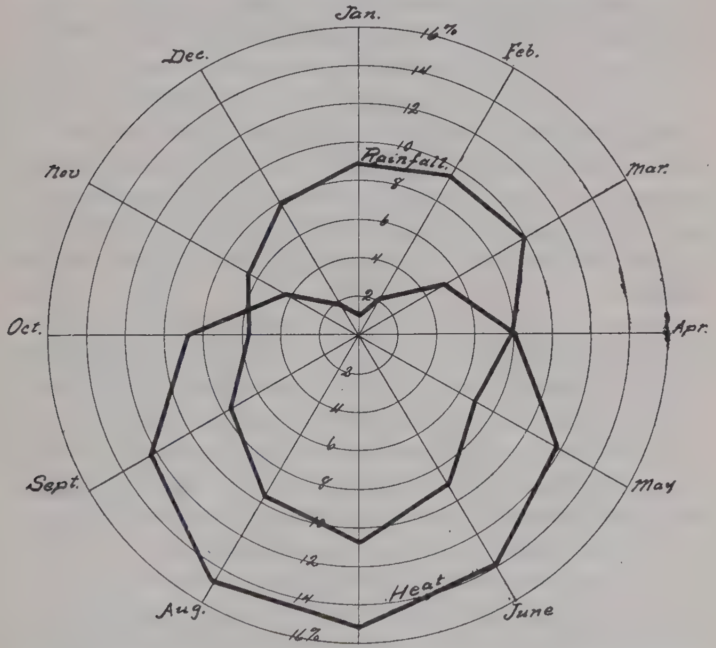


CHART 7. —MONTHLY PER CENT OF RAINFALL AND HEAT FOR THE SIX STATES: TENNESSEE, NORTH CAROLINA, SOUTH CAROLINA, MISSISSIPPI, ALABAMA, AND GEORGIA.

Annual rainfall, 50.84 in.	Average effective heat, 7440°.	Average growing season, 200 to 300 days.

Bearing this in mind, let us turn again to charts 4, 5 and 6. Although the general distribution of heat and rainfall is very similar, there is a wide difference in the amount of those elements received and particularly in the amount of heat. There is also a great difference in the length of the growing season. These differences determine largely the kind or variety of crops to be grown in each locality, but they do not and cannot have any influence on the general cropping sys-

tem to be used. In each of these localities there is a warm, wet season and a dry colder season. This distribution of heat and moisture is well adapted for a single crop system, but any attempt to use a double crop system under these conditions must fail, even where the season is long and the heat ample, for the amount of moisture will be insufficient for the second crop except in unusually wet years.

Turning to chart 7, which represents a district comprised of six states of which Atlanta is almost the exact center, we find very different conditions. Here we have two wet seasons, separated by two somewhat drier seasons. We have sufficient moisture and plenty of heat to keep the more hardy crops, as grains and grasses and winter legumes, growing throughout the year. As indicated by meteorological records, the conditions here are ideal for a double cropping system.

The farmers of the northwest are learning by experience, what the Weather Service has long indicated, that there is no moisture to spare in that region. They have been forced by climatic conditions to adopt dry farming methods, while the south is just as surely turning to the double crop system which the records also advocate. And not only are weather conditions forcing a change in cropping systems. They are also forcing a change in crops and rotations.

When the farmers of the south began to realize that their farms were deteriorating they went to the most successful farmers they could find, their brothers of the north, and asked for advice. The south was flooded with northern farm papers. The northern writers gave advice freely and with the best of intentions, but is was not applicable advice. The farms of the south continued to deteriorate and wash into the rivers, until a few of the farmers hit upon the rational idea of farming to suit the climate and began to adopt a winter cover crop. Right then they began a movement that will eventually revolutionize farming in the south.

In the search for a suitable cover crop alfalfa was tried. The northern growers of alfalfa considered it a crop adapted only to a cold climate, but experience has shown that it will do well on a variety of soils clear to the gulf when the ground has been properly prepared. Alfalfa in this case would be

an ideal crop for this climate, as it keeps the ground covered all the year round, but other cover crops are needed when only a winter cover is desired. It has been found that oats and barley among the cereals, and crimson clover and hairy vetch among the legumes, all of which are spring crops in the north, are good winter cover crops in the south. The cause is easily found in the difference in temperature and rainfall conditions. If the Weather Service has indicated these changes why may we not go to its records for aid in the solution of other problems that confront the farmer?

The double cropping system as planned and practiced at the Tennessee Experiment Station doubles the production of the farm. The increase in production that will come from the use of this system on lands that are run down will be due not only to the fact that two crops are grown instead of one, but the further fact that this system will build up the farm itself if properly applied. Briefly, the plan is to sow a grain or forage or green manure crop in the fall, turn it under or remove it in the spring or early summer, and follow with a suitable summer crop, as cotton, corn, soy beans or any other crop that best suits the purpose of the individual farmer.

The use of this system requires the practice of deep tillage in preparation of the soil, surface cultivation of cultivated crops after each rain, and the turning under of green manure to supply humus. Though the double cropping system was planned to fit the general climatic conditions of this region, these three practices are essential to its highest success, because they are the links that coordinate the efforts of the farmer with the changing weather conditions, and bind the climate, the farm and the system into an efficient crop producing machine.

The world to-day is striving for efficiency as it has never done before. The manufacturer and the merchant are cutting off every unnecessary expense. The farm can very properly be called a factory in which the power is the heat of the sun, the machinery is the rainfall that dissolves the plant food in the soil and carries it up into the plant, and the soil itself, with the elements native in it or put there by the farmer, is the material. Unlike other manufacturers, the farmer has no control of his power. The amount of heat his

farm receives cannot be increased or diminished by any effort of his, but fortunately the amount of heat received in this section is more than sufficient for any crop that could possibly be grown. The farmer can, however, determine how much of this heat he will use. If he is satisfied with a crop of cotton and leaves the ground unused in the winter he loses at least 25 per cent of the available heat. In other

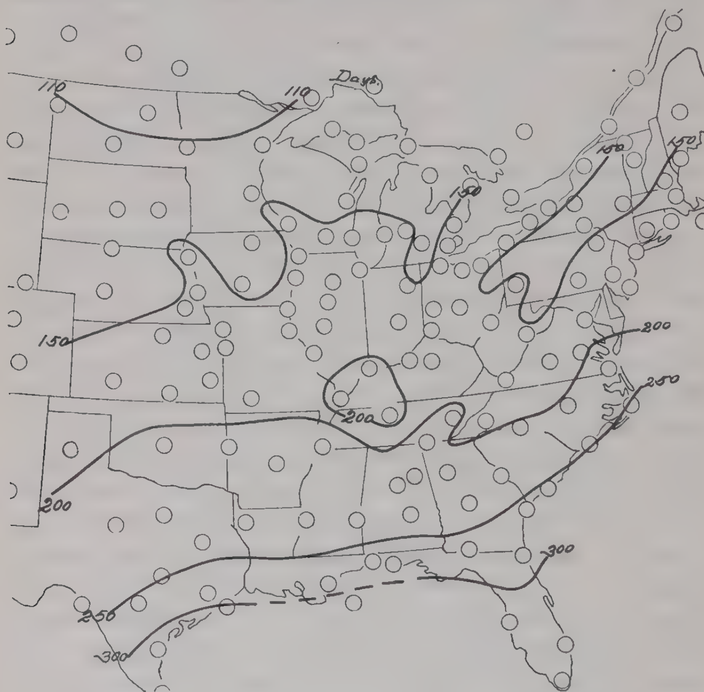


Chart 8.—Average Length of Growing Season.
(In days.)

words, he throws away one-fourth of his power. If he grows corn and does not use a winter cover crop he wastes 40 to 50 per cent of his power. The farmer who is satisfied with a crop of spring oats or some other quick-growing crop, as peas and millet (a 90-day crop), does not utilize over 45 per cent of the available energy that the sun pours on his field in a year.

But failure to keep a growing crop on the ground is not the only cause of loss of heat. Just as too little machinery in a factory for the size of the boilers will cause a waste of

fuel, so too little water in the soil will cause a waste of heat. Not only is the heat wasted but the unused heat bakes the earth, burns and stunts the crop that does grow, and destroys the bacterial flora of the soil.

This conservation of heat through utilization of rainfall brings us to a consideration of the water supply. This, too, is beyond the control of the farmer, but again the normal rainfall over this section is great enough to produce four or five times the average crop grown. Just as with heat, the farmer's problem is one of conservation. He must give his most careful thought and expend his best energy in the effort to utilize the greatest amount of the rainfall. Deep tillage with abundance of humus furnishes a reservoir for catching the rain and holding it until needed. Surface cultivation of uncovered soil prevents escape of moisture by evaporation while the growing crop with the aid of the water is using the heat to the best advantage all the year round.

Nor is the increase in the amount of time in which the heat and water are used the only gain, for in preparing the soil to conserve rainfall it has been put in the very best condition for crop production and will therefore support much heavier crops. The heavy spring rains often interfere seriously with the sowing of spring grains. For instance, the crop of spring oats was very short this year because of the heavy rains at seeding time. But those same heavy rains were a great blessing to the farmer who had sowed his oats last fall, as would always be done with the double cropping system.

Another great difficulty the southern farmer has been obliged to contend with is the curing of hay in the wet summer months. The double cropping system, with its attendant changes in crops, aids materially in the solution of this problem. The winter cereal or legume sown for a cover crop may be cut for hay during the comparatively dry month of May, and be cured with little difficulty in ordinary seasons. Again the dry season in the fall provides an excellent opportunity for curing Japan clover hay, and that crop is making great advances in the south for that very season. This is another example of the influence of climate on the acceptance of crops.

There is an old saying that opportunity knocks but once at a man's door. This opportunity in the form of abundant heat and rainfall has been knocking loudly and continuously at the door of every man who has farmed in the south. Because we have failed to hear that knock and take advantage of the opportunity we have been slowly paying the penalty inflicted on the man who hid his talent. Our soils have first been robbed of their humus and moisture-conserving power, then baked for lack of cover, then gullied and washed away. But the opportunity still knocks, and it is still possible to put these worn-out farms in better condition then they have ever been before by the practice of a system of farming adapted to climatic conditons.

For the highest efficiency in crop production we must have something more than a knowledge of general climatic conditions. A knowledge of the growing habit of each crop and its relation to temperature conditions is also necessary. Perhaps the best plant to use as an illustration of what is meant by the growing habit of plants is the soy bean. The mammoth yellow variety planted April 1 at Knoxville matured in 184 days, while the same variety plated July 15 matured in 104 days. Intermediate plantings showed that the shortening was very uniform, while similar plantings in succeeding years gave practically identical resuls. It was also noted that by far the grater part of the shortening occurred prior to blossoming. A large number of other varieties tested showed variations of the same character but very different in amount. There was also a marked difference in the character of the crop produced from the different plantings. The earliest plantings furnished a much larger amount of forage, while the later crops matured a larger amount of seed in proportion to the size of the plant.

Efficiency requires that every rotation be so planned that the crops will neither crowd one another nor have gaps between them. Of course weather conditions will sometimes interfere with the workings of the best of plans, but this will not happen more often with a good plan than with a bad plan.

Besides variations due to different dates of planting, it was found that planting the same variety on the same date

but at different places also caused a variation similar to the other. This makes it practically impossible for an experimenter to tell what these beans will do anywhere outside of the locality in which the experiment was made. For a territory as large as the six states under consideration and having so wide a range in climate, the same data must be obtained for hundreds of stations if it is to be of practical value to the farming public. To perform these experiments at hundreds of places is hardly feasible, and the large mass of climatological records that has been gathered by the Weather Bureau makes it unnecessary.

It is only necessary to determine the growing habits of the different species and varieties of farm crops adapted to the soils of any region at perhaps a dozen different places, selected to represent the whole range of climatic conditions of the district. This done, it will not be difficult to determine by interpolation what these plants will do at the hundreds of intervening stations for which the Weather Bureau has records. Work has already been begun along this line at the Tennessee Experiment Station with three varieties of soy beans. Plantings have been made at several widely separated points, and an effort will be made when the data come in to construct some kind of table or map that will show how much time these varieties require to reach maturity when planted at any given place and date.

Another broad field for the use of meteorological records for the benefit of the farmer is in connection with biological investigation. Biologists are studying the life history of many animals and plants in order to devise the best plan for their cultivation or control. Take that curse of the south, the Texas fever cattle tick, for example. It has been carefully studied at a few experiment stations, and plans have been made for moving the cattle from one pasture to another until they become tick free, and then keeping them out of the infested fields until the ticks have all starved to death. This is all very well as far as it goes, but animal life, like plant life, is largely controlled by weather conditions.

Some of the various periods in the life history of the cattle tick are greatly modified and, we might almost say, controlled by temperature conditions. For this reason a plan that is

satisfactory in every way at one station may be entirely impractical at another point, for one of two reasons. Either the time allowed for the ticks to die may be too long, causing unnecessary loss of the use of the land, or it may be too short, and when the cattle are returned to the pasture they will be reinfested. For example, investigation shows that at Dallas, Texas, the progeny of ticks dropped from the animal on May 1 will all be dead by the middle of October. At Baton Rouge, Louisiana, the progeny of ticks dropped May 1 were dead by the middle of August, and the Louisiana farmer who used the dates that were determined at Dallas would be keeping his cattle out of the pasture two months longer than necessary. But his case is not so bad as that of the Tennessee farmer would be if he tried to use the Dallas dates, for he would find to his sorrow that he had returned his cattle to the infested pasture about two months too soon.

Now, knowing how the ticks will behave at two points and knowing also the temperature conditions at those two points, it is possible to determine what the ticks will do at any other point having intermediate temperature conditions. Following this plan maps have been made and published in Bulletin 94 of the Tennessee Experiment Station, showing how long cattle must be kept out of a pasture to insure the death of all ticks. Data from more stations would probably modify these maps somewhat, but it is believed that they are approxmately correct.

Going one step farther, it seems not unreasonable to assume that with more data it will be possible to determine a direct relation between temperature and moisture conditions and the growth of plants and animals. When this can be done we can tell the inquiring farmer just how long it will take any given crop to mature in his locality, or give more definite information with reference to control of animal life.

We have seen that for the highest efficiency in farming we must know certain facts. These facts are climatic conditions and growing habits of the crops used. We have seen that for the proper control of animal life we must know the life history of the animal and its relation to temperature conditions. How are these things to be known? Can the farmer discover them for himself? This is not to be expected. Can

the Weather Bureau work it out? No; for it has only one part of the data. Can the individual experiment stations do it? Yes; in a limited way, each for its own immediate vicinity, but not in a comprehensive way that would benefit all the farmers of the nation.

This is an age of cooperation and this is a problem that requires cooperation. Just as each section of the country has its own peculiar problems, so each experiment station must have its own experiments. But if this problem is to be solved in a broad way there must be a cooperation of all the experiment stations and of all the bureaus of the Agricultural Department. If the experiment stations will each investigate the growing habits of as many crops as possible and make these investigations uniform, if the Weather Bureau will put its data in the best shape for use in the solution of this problem, and if each of the other bureaus of the Department whose activities touch on this problem in any way will cooperate heartily, it will be possible in five years to get together a mass of information that will make it possible to double and perhaps quadruple the efficiency of the farms of the south.

Study of Farm Practice vs. Field Experiments.

By W. J. Spillman,
U. S. Department of Agriculture.

Before an association the members of which are familiar with the ordinary variations of yield in field experiments, even on plots that are similar and where theoretically the yield should be the same, it is not necessary to deal at length with the limitations attending the method of investigation by field experiments. Professor Brewer used to remark that it took ten years to settle any question by this method.

Were time available I should like to deal at length with the problem of how to secure accuracy in the results of field experiments. Accurate results for a single season can be obtained by duplicating plots a sufficient number of times to give reliable averages; but variations due to difference in seasons can be overcome only by extending the work over a sufficient number of seasons to render it possible to secure a fairly accurate average of seasons. I wish more particularly in this paper to deal with the relation between accuracy of an average and the variability of the quantity measured.

I think it can be shown that a good deal of time has been wasted in attempting to secure great accuracy in certain factors of an average, while other and more important factors have been overlooked. It is an established mathematical principle that the accuracy of an average increases as the square root of the number of observations increases. Thus, other things being equal, an average based on a thousand observations is ten times as reliable as one based on ten observations.

I wish particularly to deal with the relation between the accuracy of the original observations and the reliability of the average obtained from them. For instance, suppose that in a given experiment we have one hundred plots, the yields of which are to be averaged together. How much more reliable will this average be if the yields per plot are determined to the tenth of a bushel per acre in one case, while in the other they are merely set down at the nearest

five bushels per acre? Fortunately it is possible to answer this question from existing data.

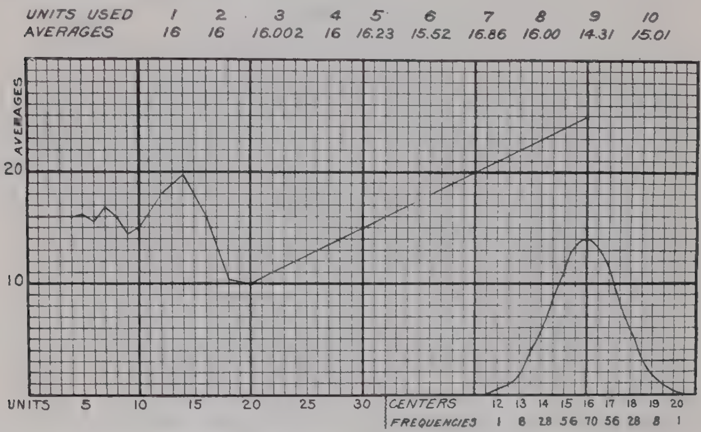


FIG. 1.—THEORETICAL FREQUENCY DISTRIBUTION AND AVERAGES RESULTING FROM USING DIFFERENT UNITS OF MEASUREMENT.

When a frequency curve is constructed from a large number of duplicate plot yields it will be found to be approximately of the form shown in the lower right-hand corner of

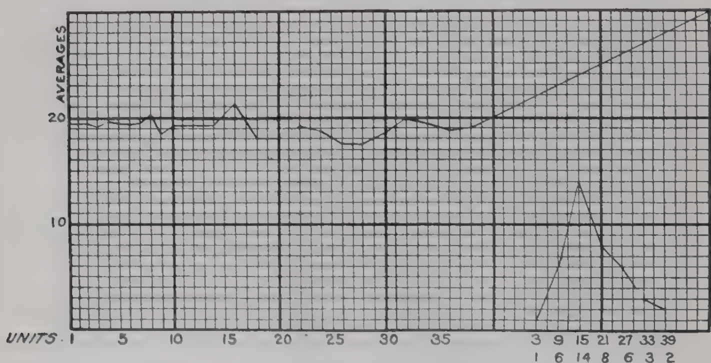


FIG. 2.—RAINFALL AT SACRAMENTO, CAL., 1849–'50 TO 1889–'90 MEASURED TO NEAREST HUNDREDTHS INCH. AVERAGES OBTAINED BY USING VARIOUS UNITS OF MEASUREMENT.

Figure 1. This represents an ideal frequency curve constructed from 256 observations. In the theoretically ideal distribution of these observations, assuming the average to be 16, and the range from 12 to 20, we should have a yield of

12 bushels once, 13 bushels eight times, 14 bushels twenty-eight times, and so on, the respective frequencies of the various yields recorded to the nearest whole bushel being given below the frequency curve in Figure 1. When any large number of comparable yields are plotted in this manner they will give a curve approximating this in form.

Figure 2 shows a similar curve constructed from 40 years' record of rainfall at Sacramento, California. Figure 3 is a frequency curve constructed from the average yield of corn by states for 46 states for the year 1893. It will be noticed that all three of these curves are of the same general form, the summit of the curve being somewhere near the middle,

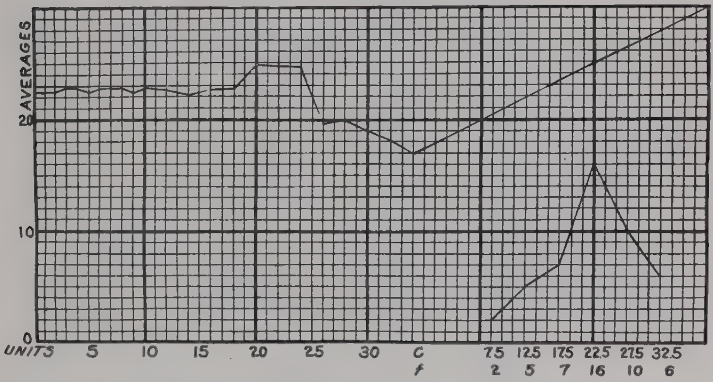


FIG. 3.—AVERAGES OF YIELD OF CORN BY STATES, 1893.

the curve sloping off in both directions. What is said below applies only to series of observations from which frequency curves similar to those shown can be plotted.

Let us now observe what happens to the average of all observations in a single case when we increase the size of the unit in which the observations are made. The first portion of Table 1 shows the theoretical distribution of the frequencies of the various yields from 12 to 20 bushels on the assumption that each yield is recorded as the nearest bushel. The first column, headed "I," shows that yields between $11\frac{1}{2}$ and $12\frac{1}{2}$ bushels are recorded as 12 bushels, those between $12\frac{1}{2}$ and $13\frac{1}{2}$ as 13 bushels, and so on. The third column shows the number of times each number of bushels would occur in an ideal distribution of yields. The fourth column is merely

the product of each number of bushels by the number of times that yield occurs. Dividing the sum of the fourth column by the sum of the third we have the average yield, which in this case is 16 bushels.

Now instead of using the bushel as our unit let us deal with these same quantities, using three bushels as the unit.

TABLE I.—256 OBSERVATIONS MADE TO NEAREST

Bushel.			
I	C	f	cf
11.5—12.5	12	1	12
12.5—13.5	13	8	104
13.5—14.5	14	28	392
14.5—15.5	15	56	840
15.5—16.5	16	70	1,120
16.5—17.5	17	56	952
17.5—18.5	18	28	504
18.5—19.5	19	8	152
19.5—20.5	20	1	20
		256	) 4,096
Average..........			16

Three bushels.			
I	C	f	cf
9—12	10.5	0.5	5.25
12—15	13.5	64.5	870.75
15—18	16.5	168.0	2,772.00
18—21	19.5	23.0	448.50
		256.0	) 4,096.50
Average............			16.002

Four bushels.			
I	C	f	cf
8—12	10	.5	
12—16	14	127.5	1,785
16—20	18	127.5	2,295
20—24	22	.5	11
		256.0	) 4,096
Average.............			16

All yields between 9 and 12 are now to be recorded as $10\frac{1}{2}$ bushels, all between 12 and 15 as $13\frac{1}{2}$ bushels, and so on. A yield which falls exactly on the dividing line between two classes is to be divided between the two. Thus, there are 56 yields of 15 bushels each. Half of these yields are counted in the group next lower and half in the group next higher. In other words, we are now measuring yields in a three-bushel measure instead of in a single bushel measure. The average yield obtained from 256 plots in this manner is seen

to be almost exactly 16 bushels. In other words, where the number of plots to be averaged is 256, a three-bushel measure

TABLE II.—RAINFALL AT SACRAMENTO, 1849–50 TO 1889–90.

Annual totals.	Ten year average.	Dif. from 40-year averages.	% of differ-ence.	Units of meas-ure-ment.	Corre-sponding averages.	Differ-ence.	% of 19.57.
Inches.				*Inches.*			
36.00	....	....	....	0.01	19.57	....	....
4.71	....	....	....	1	19.68	+ .11	.56
17.95	....	....	....	2	19.40	− .15	.77
36.36	....	....	....	2	19.20	− .37	1.89
20.06	....	....	....	4	19.70	+ .13	.66
18.62	....	....	....	5	19.50	− .07	.36
13.76	....	....	....	6	19.35	− .22	1.12
10.46	....	....	....	7	19.60	+ .03	.15
15.00	....	....	....	8	20.40	+ .83	4.24
16.03	18.90	.67	3.42	9	18.22	− 1.35	6.90
22.09	....	....	....	10	19.25	− .32	1.63
16.10	....	....	....	12	19.25	− .32	1.6
35.56	....	....	....	14	19.25	− .32	1.63
11.58	....	....	....	16	21.20	+ 1.63	8.33
7.87	....	....	....	18	18.00	− 1.57	8.02
22.51	....	....	....	20	18.00	− 1.57	8.02
17.93	....	....	....	22	19.25	− .32	1.63
25.30	....	....	....	24	18.60	− .97	4.95
32.79	....	....	....	26	17.55	− 2.02	10.32
16.64	20.84	1.27	6.49	28	17.50	− 2.07	10.57
13.57	....	....	....	30	18.75	− .82	4.19
8.47	....	....	....	32	20.00	+ .43	2.20
23.65	....	....	....	34	19.47	− .10	.51
14.21	....	....	....	36	18.90	− .67	3.42
22.90	....	....	....	38	19.00	− .57	2.91
17.70	....	....	....	40	20.00	+ .43	2.20
26.53	....	....	....	42	21.00	+ 1.43	7.31
8.96	....	....	....	44	22.00	+ 2.43	12.40
24.86	....	....	....	46	23.00	+ 3.43	17.50
17.85	17.87	1.70	8.69	48	24.00	+ 4.43	22.60
26.47	....	....	....	50	25.00	+ 5.43	27.70
26.57	....	....	....	100	50.00	+30.43	....
16.51	....	....	....	....	....	....	....
18.11	....	....	....	....	....	....	....
24.78	....	....	....	....	....	....	....
16.58	....	....	....	....	....	....	....
32.27	....	....	....	....	....	....	....
13.97	....	....	....	....	....	....	....
11.56	....	....	....	....	....	....	....
19.95	20.68	1.11	5.67	....	....	....	....

19.57 40-year average.

gives approximately the same average as a one-bushel measure. The last part of Table 1 shows the result when we use a four-bushel measure, counting everything between, say,

16 and 20 bushels as 18 bushels, and so on. Here again the average is exactly 16.

The upper curve in Figure 1 carried these results further. The figures below the curve show the size of the unit used in measuring yields. The curve shows that when the unit of measurement is less than 5 bushels, the average obtained is practically the same. In other words, there is no gain of accuracy by using a bushel measure as compared with using a four-bushel measure in obtaining the yields of these plots where the yields are between 12 and 20 bushels. If, however, we use a five-bushel measure the average runs a little above 16. With a six-bushel measure the average is about $15\frac{1}{2}$. Beyond this point the averages become very unreliable. It will be noticed in this case that as long as the unit of measure used is not greater than half the range of variation of the yields to be averaged no inaccuracy results from using the coarser unit of measure.

Let us now apply this reasoning to actual figures. Table 2 relates to the annual rainfall at Sacramento for a period of forty years. The lowest rainfall during this period was 4.71 inches; the highest 36.36. It happens also that these two rainfalls occurred within two years of each other. Here we are dealing with a highly variable quantity, but one which is quite comparable with the yield on the same plot in different seasons. I would first call your attention to the average rainfall for the first ten-year period. It is seen to be 18.9 inches. A field plot which is continued for ten years is supposed to give fairly accurate averages. During the second ten years the average rainfall was 20.84; the third, 17.87, and the fourth 20.68. The forty-year average is 19.57. The difference between the various ten-year averages and the forty-year average, expressed in per cent of the latter, is seen to be 3.42, 6.49, 8.69, and 5.67. This shows something of the relative accuracy of a forty-year average and a ten-year average.

In the right-hand portion of Table 2 is given the averages of the forty years obtained by using different units of measurement. The first average is that given in the first column of Table 2, where the unit of measurement is .01 of an inch. The second average of 19.68 is found by taking the nearest

whole inch instead of the actual rainfall as determined by measurement. The next average is found by using two inches as the unit for recording annual rainfall. Thus, everything between 10 and 12 inches is recorded as 11 inches, everything between 12 and 14 inches as 13 inches, and so on.

The interesting thing about this table is that any unit of measurement smaller than 24 inches gives an average as close to the forty-year average as some of the ten-year averages based on the most accurate figures. The per cent of error does not reach 2 per cent until a unit larger than 7 inches is used for recording the measurements, and the error does not exceed 10 per cent until the unit of measurement used reaches 26 inches.

The meaning of this table may be made a little clearer by considering one of these averages more in detail. Where 20 inches is used as the unit of measurement any rainfall less than 20 inches is recorded as 10 inches, and any rainfall between 20 and 40 inches is recorded as 30 inches. Since in no year did the rainfall exceed 40 inches, the average rainfall in this case is obtained merely by recording each year's rainfall either as 10 inches or as 30 inches, according as it falls below or exceeds 20 inches.

The deduction to be drawn from these facts is that large numbers of observations are very much more important than a high degree of accuracy in single observations. The facts here presented appear to justify the statement that a very satisfactory degree of accuracy in the average rainfall at a given point could be obtained if, for a period of a hundred years we could get the guesses of a number of people who can make fairly accurate guesses whether or not the rainfall each year was greater or less than some number of inches near the average rainfall. At least, in the figures of Table 2 it is seen that the error in such a method would not be over 10 per cent.

Figure 3 and Table 3 apply these principles to the average of the yield of corn in the various states for the year 1893. The average of all the yields is 22.63 bushels. Taking the same figures and reducing them to the nearest bushel, this average becomes 22.66. Reducing them to the nearest five bushels the average is 22.4 bushels. When expressed as the

nearest ten bushels the average is 22.82 bushels. The average obtained from these 46 numbers does not differ as much as 2 per cent from the most accurate average until the unit of measurement used exceeds 18 bushels per acre, which is considerably more than half of the range of the various numbers averaged. These numbers range from 7.7 bushels to 33.9 bushels. The departures from the most accurate average, when larger and coarser units of measurements are used,

TABLE III.—AVERAGE OF AVERAGE YIELDS OF CORN BY STATES.

1893 YB. 1894—46 States.

Units.	Average.	Difference.	% of 22.63.
1	22.63	....	....
1	22.66	+ .03	.13
2	22.48	+ .15	.66
3	22.77	+ .14	.62
4	22.79	+ .16	.71
5	22.40	− .23	1.02
6	22.70	+ .07	.31
7	22.82	+ .19	.84
8	22.96	+ .33	1.46
9	22.50	− .13	.57
10	22.82	+ .19	.84
12	22.70	+ .07	.31
14	22.22	− .41	1.81
16	22.60	− .30	.13
18	22.70	+ .07	.31
20	23.90	+1.27	5.61
22	23.44	+ .81	3.58
24	23.50	+ .87	3.84
26	19.78	−2.85	12.60
28	20.09	−2.54	11.20
30	18.91	−3.72	16.40
32	18.08	−4.55	20.10
34	17	−5.63	24.90
36	18	−4.63	20.45
38	19	−3.63	16.04
40	20	−2.63	11.61
Etc.	....	....	....

are shown in Figure 3. It is seen that when the unit of measurement is anywhere between .1 of a bushel and 18 bushels the average obtained lies between 22 and 23 bushels.

What has been said above applies to all averages of quantities which fluctuate about a mean and in which there are considerable differences between the individual quantities. It applies to averages of yields of duplicate plots. I have

seen in a bulletin, which purports to represent very scientific work, yields of 5 bushels and 45 bushels averaged in the same column. In the adjoining column yields of 8 bushels and 48 bushels are averaged together. The difference between the two averages is about one-third of a bushel, yet important deductions are drawn based upon this difference. How much less accurate would be the averages of the guesses of 200 intelligent farmers? Fortunately we have some data that will enable us to answer this question, at least partially.

In a farm management survey made by Mr. F. E. Robertson, of the Office of Farm Management in the State of New Hampshire, one of the questions asked the farmers was, "How many pounds of milk have you sold during the past year?" Another, "What is the estimated value of the milk?" Seventy-nine farmers answered the first question and 135 farmers the second. Later the exact figures were obtained from the creameries to which this milk was sold. Table 4 shows the comparison between the farmers' estimates and the actual figures obtained from the creamery:

TABLE 4.

Estimated pounds of milk sold (79 farms)....	3,518,816 lbs.
Actual pounds of milk sold (79 farms)........	3,487,320 lbs.
Difference..........................	31,496 lbs.
Estimated value of milk sold (135 farms).....	$106,163.00
Actual value of milk sold (135 farms)........	106,155.00
Difference..........................	$7.50

The farmer is not in the habit of thinking in pounds of milk, and it was to be expected that his estimates on this point would be less accurate than his estimates of the money obtained for the milk sold. Furthermore, the number of answers to the first question is smaller than to the second, thus making the average obtained less reliable. It is seen that the error in the farmers' estimates of the amount of milk sold is less than one per cent of the total, while in the case of the money received for milk sold the error is .00¾ of 1 per cent.

In the case of both pounds of milk sold and money received the estimates of individual farmers fluctuated from about 50 per cent too high to about 40 per cent too low.

It may be surprising to many that the totals of the above estimates of farmers agree so well with the actual quantities which were later definitely determined, especially when it is remembered that in individual cases the farmers' estimates were in error as much as 50 per cent. I think it is probable that the average of a large number of farmers' estimates would not,in general, be as accurate as the cases I have cited, but this might be and the averages still be more accurate than those obtained in ordinary field experiments.

The important thing to remember is that when we are conducting an experiment with a view to determining what the actual yield of a given crop under a given set of conditions would be, on the average of a series of years, we are at no time actually measuring the quantity we are trying to find. Suppose, for instance, that the true average for the conditions under which we are working is 30 bushels per acre, while this year the yield is 19.16 bushels. No matter how accurately we measure the yield this year there is an error of about 11 bushels in the measurement, and this error is in no way eliminated by carrying this year's yield out to the second decimal place. A high degree of accuracy in the individual measurements of a quantity which is thus highly variable does not mean a high degree of accuracy in the average obtained. A large number of measurements to be averaged is much more important than a high degree of accuracy in the individual numbers.

The question now arises whether the average of a large number of estimates by farmers is not more accurate than the results obtained in ordinary plot experiments in the field. In other words, for those problems the data for which actually exist on the farms of the country can we not get a more reliable solution by gathering these data in large quantities than we can by ordinary experimental methods? The figures presented above indicate that we can. We all recognize that there are many problems the solution of which does not exist on farms, and that in the study of these problems we must use the more expensive and less accurate method of field

experiment; but the solution of numerous problems does exist on the farms of the country to-day. Is it not the part of wisdom to obtain these solutions by a method which appears to be more accurate, and is certainly less expensive, than that in common use?

One other important point. In the attempt to solve farm problems by the study of results actually obtained by farmers the opportunity is presented of ascertaining what are the actual problems confronting the farmer. Frequently these are problems of which the farmer himself has never suspected the existence. But the well-trained student of farm practice does see them. He also comes to recognize what problems have been solved in farm experience and what have not. He is thus in position to plan experimental work that will give results of importance, a thing not always true of experiments planned by those who have not made a thorough study of farm practice.

DR. MELVILLE A. SCOVELL,
Director Kentucky Experiment Station,
1855–1912.

IN MEMORIAM.

DR. MELVILLE AMASA SCOVEL.

1855—1912.

In the spring of 1889, while engaged with my duties at the University of Illinois, I was approached one day by an acquaintance accompanied by an alert stranger who was introduced as Professor Scovell, Director of the Kentucky Agricultural Experiment Station. Professor Scovell was looking for some one to fill the position of Entomologist and Botanist of the Kentucky Station, and his offer to me of the place led to a trip of observation which was made to Lexington shortly after his visit.

The Kentucky Station was found to be in marked contrast with the institution in Illinois, and the proposed change meant giving up all the laboratory, library and other facilities one could desire or expect, to become connected with an institution but just started, indeed almost in embryo. But Professor Scovell's enthusiasm was infectious. It had already impressed his Board, the members of which, to their great credit, stood solidly at his back; and it was evident that such an association would make things move. I joined the staff July 1, and have been with it to the present time.

A small office and laboratory had been improvised in the basement of one of the buildings belonging to the State A. and M. College, and here were at work the whole office and laboratory staff of the new station, consisting of the director and two chemists. There was no place for a fourth; but a small new building was in process of construction which was to accommodate both the Station and the Chemical Department of the College. A farm of 48.5 acres located a short distance from the city limits had recently been purchased, and a farm superintendent had been engaged to look after such experiments and tests as were to be made.

The building up of the Station was thus to be pioneer work. The task was one requiring, in Kentucky, tact, intelligence and persistence. Professor Scovell proved throughout his life, ending from heart failure August 15, 1912, that he possessed every one of these qualities in an eminent degree. His life-work may be said to have consisted in putting the Kentucky Experiment Station on a secure and ample foundation. It was here that his special faculty of securing the confidence of those with whom he came in contact appeared. In the early days of the Station's history farmers were suspicious of those they regarded as book farmers. They were not ready to vote funds for them. They had little use for any thing but practical experience. There might be a hidden motive behind professions of zeal for the improvement of the farmer's condition. The ever-present politics loomed up as a possible explanation of activity of this sort. Where was the graft in it?

Professor Scovell was largely instrumental in allaying this feeling before he died, and if he had done nothing else, would deserve well of Kentucky. He was effective as a pacifier. He made friends. He allayed suspicion. He secured support. These things were what the Station most needed, and it was this faculty more than any other that made him an effective man in his position. Many of the other stations had something with which to begin: he had nothing. Many were at least in a congenial environment: he had to make one. Many had laboratories, books, land, had even some experimental work along agricultural lines to their credit: he had nothing of this sort behind him. It was a task suited to one of his temperament. He devoted himself to it at a good deal of personal sacrifice as a scientific man and chemist, for it meant a life devoted to business rather than science—to providing means for scientific work rather than doing it.

How well he accomplished his work is apparent on comparing the present condition of the Station with its condition in the spring of 1889.

The two men who were working at that time in the basement of the main building of the college (now a university) are still here. But the staff increased during Professor Scovell's lifetime from three to sixty; the departments from two to

eleven; the farm from 48.5 acres to 240, with additional tracts scattered about the State. While in 1889 the work of the Station consisted largely of analysis of fertilizers and tests of fertilizers on the farm, the activities of the Station workers now range over an extensive field, including studies of waters, soils, fungus and insect injuries to crops, rotations, variety tests, animal diseases, fruits and fruit growing, and, in short, the whole subject of agriculture as far as it is considered of importance to Kentucky. Coupled with this work, a great deal more is being done in the way of inspection of nurseries and orchards under a State law, and of fertilizers, seeds, feeds, foods and drugs, also under State laws.

From a condition of extreme feebleness in 1889 the Station has steadily gained in strength until in 1912 it had become one of the three or four strongest in the country in the matter of resources. This brief statement tells the whole story of Professor Scovell's management of its affairs.

The securing of funds to carry on the work of the Station was not the only outlet for Professor Scovell's enthusiasm. He was active in getting started and building up the State Fair, an institution greatly needed by Kentucky for the improvement of her agriculture, and one which has already accomplished much in stimulating an interest in good stock and in improved varieties of grain, vegetables and fruits. His interest in the various national organizations of agricultural workers was also of the keenest, and he never spared himself in working for their success. The friendships formed during the meetings of these organizations were a source of very great pleasure to him. Indeed I think he got more enjoyment from meeting his friends and mixing with them than from anything else having to do with his duties as a director. He was apparently never happier than when in a crowd, and completely identified himself with any party he might join. The collective psychology of an association, whatever it might be, was his psychology. He was a socialist, in a broad sense, rather than an individualist.

Shortly after the death of Professor Scovell the writer had occasion to make a flying trip to Illinois and there happened upon a county fair at which the University of Illinois had an exhibit. In charge were young men of the Agricultural

Department of the University, some of whom were soliciting subscriptions for a university stock paper. Being unknown to them, I was urged to subscribe, and my interest and curiosity were aroused by the statement that the most recent issue of the paper contained an article by "the foremost authority on Jersey cattle in the country." A glance over the pages of a copy showed that the article was written by Professor Scovell. It was one of the few articles of any sort written by him. He was a good judge of Jerseys, and was from the first days of his directorship an admirer of the breed. The herd which he gradually assembled on the Experiment Farm was his one hobby, and received from him special thought and care. He knew the pedigree of every animal in it. From it as a nucleus he was continually extending his knowledge of cattle and dairying. In the latter part of his life he had an opportunity to indulge his taste in this direction without stint, and bought for the Elmendorf farm at Lexington some of the finest and most costly Jerseys in the world. His judgment in the selection of these animals has since been abundantly justified by numerous premiums taken wherever they have been exhibited, and they have been pitted against the best Jerseys in the United States. If not the foremost judge of Jerseys in the country, it is no disparagement of others to say that he was certainly among the first.

I write at some disadvantage concerning his purely scientific work. It was done almost entirely before I made his acquaintance. The management of the business of the Station so engrossed his attention that he found little time for anything else. I suppose this has been the experience of other directors. Yet the work done on cane juices at the University of Illinois while associated with Prof. H. A. Weber showed that he was effective as an investigator, and it is not too much to say that if he had continued his studies as a chemist he would have taken high rank among the industrial chemists of the country.

H. GARMAN.

DR. JOHN B. SMITH,
ENTOMOLOGIST, NEW JERSEY EXPERIMENT STATION,
1858–1912.

DR. JOHN BERNHARDT SMITH.

1858—1912.

When the state agricultural experiment stations were founded under the Hatch Act, it was difficult in certain lines of work to secure competent men, and this was especially so in regard to economic entomology. There were very few well-trained economic entomologists then in the country, and for the most part stations taking up entomological work were obliged to appoint either untrained men or to take men who had established some reputation for themselves as entomologists without having engaged in directly practical work, while in other cases the entomological work was handled by the agriculturist or the horticulturist of the station.

New Jersey appointed, as her first entomologist, Rev. Dr. George D. Hulst, a man who had made his entomological reputation by working upon a family of moths. He served for only a year, and in 1889 Dr. John Bernhardt Smith took his place and remained connected with the station from that time until March 12, 1912, when he died at his home in New Brunswick.

Dr. Smith was one of the most prolific writers on economic entomology which this country has seen, and his work was sound. During the twenty-two years of his active work in economic entomology, he built up a reputation for himself and for his State second to that of no individual or institution. During the first year of his appointment, he issued four special bulletins of much value, and from that time on he handled in a masterly way every entomological emergency that made its appearance.

Dr. Smith was born in November 21, 1858, in New York City, of German parentage, and was educated in the public schools. He was admitted to the bar in 1880, and practiced law in Brooklyn between 1880 and 1884. He was greatly interested in insects, joined the Brooklyn Entomological Society of that time, and became editor of the bulletin of that society. This publication he afterwards developed into a periodical known as "*Entomologica Americana,*" which

became an important vehicle for the publication of smaller papers and notes. In 1884, he was made special agent of the Division of Entomology, U. S. Department of Agriculture, and for two years did field work, especially upon insects affecting the hop and cranberry. This was his first introduction to economic entomology. In 1886, he was made aid in the Division of Insects of the U. S. National Museum, and held this position until he was appointed to his final position in New Jersey. During the four years he was connected with the National Museum it is true that his work was all of a systematic character and that he did no actual work in economic entomology, but he was a member of the Entomological Society of Washington and was constantly associated with the men of the Division of Entomology, U. S. Department of Agriculture, and followed their work intimately and discussed it with them; so that he really lived in an atmosphere of practical work.

With the founding of the Association of Economic Ent - mologists, an organization which has made a great impreos on practical entomology, not only in this country but sn other parts of the world, Dr. Smith was made the secretariy of the association and held this office for two years. He was made second vice-president in 1893, first vice-president in 1894, and president in 1895. His address as retiring presi- was entitled, "Entomological Notes and Problems," and was delivered August 27, 1895, at Springfield, Mass. It was a thoroughly practical address, dealing with all the phases of the work which the then new body of officials were engaged upon.

Dr. Smith's bibliography covers hundreds of titles. His industry was enormous. He not only made his office a noted one for its practical work, but he maintained all through his career an active interest in every phase of entomological research. He published, for example, two great catalogues of the insects in New Jersey and very many systematic papers upon that Lepidopterous family, Noctuidæ. He also published privately two excellent books: "Economic Entomology for the Farmer and Fruit Grower" (Lippincott, 1896), one "Our Insect Friends and Foes" (Lippincott, 1909).

His latest work, and that which perhaps brought him the

most fame, was that with the New Jersey mosquitoes. He was the first entomologist who realized and who proved that the banded-legged mosquitoes of the Atlantic coast must differ widely in habit and mode of life from the rain water-barrel mosquitoes and the woodland mosquitoes of the interior; and he found that these salt-marsh mosquitoes breed in the salt marshes and that their eggs are not laid in the water but on the mud and that they fly a distance of from thirty to forty miles. These claims seemed revolutionary to earlier students of mosquitoes, but he proved his case beyond doubt and succeeded finally in securing a large appropriation from his State, and in demonstrating that it is possible at a comparatively slight expense to control even these wild-salt-marsh forms.

Dr. Smith's death is a great loss to the State of New Jersey and to American economic entomology.

L. O. Howard.

LIST OF OFFICERS AND MEMBERS

OF THE

Society for the

Promotion of Agricultural Science

1913

OFFICERS FOR THE SOCIETY FOR 1913.

President—Eugene Davenport, *Urbana, Illinois.*
Secretary-Treasurer—E. W. Allen, Department of Agriculture, *Washington, D. C.*
Custodian—W. J. Beal, *Amherst, Mass.*
Assistant Custodian—W. D. Hurd, *Amherst, Mass.*
Executive Committee:
W. H. Jordan, *Geneva, New York.*
H. P. Armsby, *State College, Pennsylvania.*
H. L. Russell, *Madison, Wisconsin.*

Past Presidents.

Term began		*Expired*
1880	W. J. Beal, *of Michigan*	1882
1881	W. H. Brewer, *of Connecticut*	1884
1884	H. E. Alvord, *of New York*	1886
1886	E. L. Sturtevant, *of New York*	1887
1887	R. C. Kedzie, *of Michigan*	1889
1889	C. E. Bessey, *of Nebraska*	1891
1891	I. P. Roberts, *of New York*	1893
1893	W. Saunders, *of Ontario, Canada*	1895
1895	W: R. Lazenby, *of Ohio*	1897
1897	B. D. Halsted, *of New Jersey*	1899
1899	W. J. Beal, *of Michigan*	1901
1901	W. H. Jordan, *of New York*	1903
1903	William Frear, *of Pennsylvania*	1905
1905	H. P. Armsby, *of Pennsylvania*	1907
1907	T. F. Hunt, *of Pennsylvania*	1909
1909	S. M. Tracy, *of Mississippi*	1911
1911	Eugene Davenport, *of Illinois*	

Past Secretaries.

1880	E. L. Sturtevant, *of Massachusetts*	1882
1882	G. C. Caldwell, *of New York*	1883
1883	F. A. Gulley, *of Mississippi*	1885
1885	B. D. Halsted, *of Iowa*	1886
1886	W. R. Lazenby, *of Ohio*	1891
1891	L. O. Howard, *of District of Columbia*	1893
1893	W. Frear, *of Pennsylvania*	1895
1895	C. S. Plumb, *of Indiana*	1899
1899	T. F. Hunt, *of Ohio*	1900
1900	F. M. Webster, *of Illinois*	1905
1905	F. W. Rane, *of Massachusetts*	1910
1910	E. W. Allen, *of District of Columbia*	

MEMBERSHIP OF THE SOCIETY.

Honorary Member.

1899. Hon. James Wilson, LL. D., *Traer, Iowa.*

Regular Members.

[Arranged Alphabetically.]

The prefixed date is the year of election.

1907. Edwin West Allen, B. S. (Mass. Agr. Coll. and Boston Univ., '85), Ph. D. (Göttingen, '90); *U. S. Dept. Agr., Washington, D. C.;* Asst. Chem. Mass. Expt. Sta., '85–'88; Asst. Office Expt. Stas., '90–'93; Asst. Dir., do., '93—; Ed. Expt. Sta. Record, '95—.

1889. Henry Prentiss Armsby, B. S. (Worcester Poly. Inst., '71), Ph. B. (Sheffield Sci. School, '74), Ph. D. (Yale Univ., '79), LL. D. (Univ. Wis., '04); *State College, Pa.;* Chem. Conn. Expt. Sta., '77–'81; Vice Prin. Storrs Agr. School, '81–'83; Prof. Agr. Chem., Univ. Wis., '83–'87; Dir. Pa. Expt. Sta., '87–'07; Dean School of Agr., Penn. State College, '95–'02; Dir. Inst. Animal Nutrition, '07—.

1886. Joseph Charles Arthur, B. S. (Iowa State Coll., '72), M. S. (do., '77), D. Sc. (Cornell Univ., '86); *Lafayette, Ind.;* Instr. Biol., Iowa State Coll., '76–78; Instr. Bot., Univ. Wis., '79–'81; do., Univ. Minn., '82; Bot. N. Y. Expt. Sta., '84–'87; Prof. Bot., Purdue Univ., '87–88; Prof. Veg. Phys. and Path., do., and Bot., Ind. Expt. Sta., '88—.

1906. Liberty Hyde Bailey, B. S. (Mich. Agr. Coll., '82), M. S. (do., '85), LL. D. (Univ. Wis., '07); *Ithaca, N. Y.;* Prof. Hort. and Landscape Gardening, Mich. Agr. Coll., '84–'88; Prof. Hort., Cornell Univ., '88–'03; Dir. Coll. Agr. and Expt. Sta., Cornell Univ., '03—.

1909. Walter Henry Beal, A. B. and M. E. (Va. Poly. Inst., '86); *Washington, D. C.;* Asst. Chem. Mass. Expt. Sta., '87–'91; Asst. Office of Expt. Stas., U. S. Dept. Agr., '91–'02; Chief of Editorial Division, do., '02—.

1879. William James Beal, A. B. (Univ. Mich., '59), A. M. (do., '63), Sc. B. (Harvard Univ., '65), Sc. M. (Univ. Chicago, '75), Ph. D. (Univ. Mich., '80), D.Sc. (Mich. Agr. Coll., '05); *Amherst, Mass.;* Prof. Bot., Mich. Agr. Coll., '70–'72; Prof. Bot. and Hort., '72–'81; Prof. Bot. and Forestry, '81–'03; Prof. Bot., '03–'10; Prof. Emeritus, '10—.

1880. Charles Edwin Bessey, B. Sc. (Mich. Agr. Coll., '69), M. Sc. (Mich. Agr. Coll., '72), Ph. D. (State Univ. Iowa, '79), LL. D. (Iowa Agr. Coll., '98); *Lincoln, Nebr.;* Prof. Bot., Iowa Agr. Coll., '70–'84; Prof. Bot., Univ. Nebr., '84—; Acting Pres. Iowa Agr. Coll., '82; Acting Chancellor Univ. Nebr., '88–'91, and '99–'00; Dean Industrial Coll., Univ. Nebr., '84–'88, and '95—; Dean Coll. of Literature, Science and Arts, '88–'91; Dir. Nebr. Expt. Sta., '87–'89; Head Dean of Univ., '09—.

1912. Augustine Wilberforce Blair, B. S. (Haverford, '92), A. M. (do., '96); *New Brunswick, N. J.;* Prof. Chem., Guilford Coll., '96–'97; Asst. Chem., N. C. Expt. Sta., '97–'98; State Chem., N. C., '98–'99; Asst. Chem., Fla. Expt. Sta. and Univ. Fla., '99–'06; Chem., Fla. Expt. Sta., '06–'12; Assoc. Soil Chem.. N. J. Expt. Sta., '12—.

1893. Henry Luke Bolley, B. S. (Purdue Univ., '88), M. S. (do., '89); *Agricultural College, N. Dak.;* Instr. Biol. amd Asst. Bot. to Expt. Sta., Purdue Univ., '90; Prof. Bot. and Plant Path., N. Dak. Agr. Coll. and Bot. and Plant Path of Expt. Sta. do., '90—.

1909. William Penn Brooks, B. Sc. (Mass. Agr. Coll., '75), Ph. D. (Halle, '97); *Amherst, Mass.;* Prof. Agr. Imp. Coll. Agr., Sapporo, Japan, '77–'88; Prof. Bot., do., '81–'88; Pres., do., *ad interim* '80–'83, and '86–'87; Prof. Agr. and Agr., Mass. Agr. Coll. and Expt. Sta., '89–'09; acting Pres. and Dir., do., '05, '06; Dir. Expt. Sta., '06—.

1905. Burt C. Buffum, B. S. (Col. Agr. Coll., '90), M. S. (do., '93); *Worland, Wyo.;* Asst. Met. and Irr. Eng., Col. Agr. Coll., '90–'91; Prof. Hort. and Met., Univ. Wyo. and Bot. Wyo. Expt. Sta., '91–'92; Prof. Agr. and Hort., do., '91–'00; Vice Dir. do. Expt. Sta., '96–'00; Prof. Agr., Col. Agr. Coll., '00–'02; Dir. Wyo. Expt. Sta., and Prof. Agr. and Hort., Univ. Wyo., '02–'07; Plant Breeder and Mgr. Wyo. Seed Breeding Co., '07—.

1901. Edgar Allen Burnett, B. S. (Mich. Agr. Coll., '87); *Lincoln, Nebr.;* Asst. Mich. Agr. Coll., '89–'93; Prof. An. Husb., S. Dak. Agr. Coll., '96–'99; Prof. An. Husb., Univ. Nebr., '99–'07; Dir. Nebr. Expt. Sta., '01—; Dean Coll. Agr., '09—.

1908. Kenyon L. Butterfield, B. S. (Mich. Agr. Coll., '91), A. M. (Univ. Mich., '02); *Amherst, Mass.;* Supt. Mich. Farmers' Institutes, '95–'99; Instr. Univ. Mich., '02; Pres. Rhode Island Coll., '03–'06; Pres. Mass. Agr. Coll. and Head Div. Rural Sociol., '06—.

1909. Frank Kenneth Cameron, A. B. (Johns Hopkins, '91), Ph. D. (do., '94); *Washington, D. C.;* Fellow Cornell, '94–'95; Assoc. Prof., Catholic Univ., '95–'97; Asst. Physical Chem., Cornell, '97–'98; Expert, U. S. Dept. Agr., '98–'99; Soil Chemist, do., '99—.

1908. Mark Alfred Carleton, B. S. (Kans. Agr. Coll., '87), M. S. (do., '93); *1112 Morris Bldg., Philadelphia, Pa.;* Asst. Bot.,

Kans. Expt. Sta., '92–'93; Cerealist, Bur. Plant Indus., U.S. Dept. Agr., '94–'12; Gen. Mgr., Penn. Chestnut Tree Blight Com., '12—.

1905. LOUIS GEORGE CARPENTER, B. S. (Mich. Agr. Coll., '79), M. S. (do., '84), LL. D. (do., '07); *707 First Nat. Bank Bldg., Denver, Col.;* Asst. Prof., Mich. Agr. Coll., '85–'88; Irr. Eng., Col. Agr. Coll. and Expt. Sta., '88–'10; Dir. Expt. Sta. do., '99–'10; State Eng., '03–'05; Consulting Irrigation Engineer, '10—.

1901. LOUIS ADELBERT CLINTON, B. S. (Mich. Agr. Coll., '89), M. S. (do., '97); *U. S. Dept. Agr., Washington, D. C.;* Asst. to Dir. Mich. Expt. Sta., '89–'93; Asst. Prof. Agr., Clemson Coll., '93–'95; Asst. Agr., Cornell Expt. Sta., '95–'02; Dir. Storrs Expt. Sta. and Prof. Agr., Conn. Agr. Coll., '02–'12; Agriculturist, Bur. Plant Indus., '12—.

1910. JOHN WALDO CONNAWAY, D. V. S. (Chicago Vet. Coll., '90), M. D. (Univ. Mo., '91); *Columbia, Mo.;* Prof. Physiology, Univ. Mo., '91–'97; Vet. Expt. Sta., do., '97–'00; Prof. Compar. Med. and Vet. to Expt. Sta., Univ. Mo., '00—.

1910. LEE CLEVELAND CORBETT. B. S. (Cornell Univ., '90), M. S. (do., '96); *Washington, D. C.;* Asst. Hort., Cornell Univ., '91–'93; Prof. Hort. and Forestry, S. Dak. Coll., '93–'95; do., Univ., W. Va. and Expt. Sta., '95–'01; Hort., U. S. Dept. Agr., '01–'13; Asst. Chief, Bur. Plant Indus., do., '13—.

1902. CHARLES FRANCIS CURTISS, B. S. A. (Iowa State Coll., '87), M. S. A. (do., '93), D. Sc. (Mich. Agr. Coll., '07); *Ames, Ia.;* Asst. Dir. Iowa Expt. Sta., '91–'97; Prof. Agr. and Acting Dir., Iowa Expt. Sta., '97–'00; Prof. Agr. and Dir., do., '00–'02; Dean and Dir., '02—.

1911. WILLIAM HADDOCK DALRYMPLE, M. R. C. V. S. England, '86; *Baton Rouge, La.;* Prof. Vet. Sci., La. State Univ., '89—; Vet., La. Expt. Sta., '89—.

1906. EUGENE DAVENPORT, B. S. (Mich. Agr. Coll., '78), M. S. (do., '81), M. Agr. (do., '95), LL. D. (do., '07); *Urbana, Ill.;* Prof. Agr., Mich. Agr. Coll., '89–'90; Dir. Coll. of Agr., Piracicaba, Brazil, '91–'92; Dean Coll. of Agr., Univ. Ill., '95—; Dir. Agr. Expt. Sta., '96—.

1911. WILLIAM RUFUS DODSON, B. S. (Univ. Mo., '90), A. B. (Harvard Univ., '94); *Baton Rouge, La.;* Asst. Biol., Univ. Mo., '90–'93; Prof. Bot., La. Univ., '94–'02; Asst. Dir., La. Expt. Stas., '02–'05; Dir., do., '05—; Dean, Coll. Agr., La. Univ., '09—.

1897. BENJAMIN MINGE DUGGAR, B. S. (Miss. Agr. Coll., '91), M. S. (Ala. Poly. Inst., '92), A. B. (Harvard Univ., '94), A. M. (do., '95), Ph. D. (Cornell Univ., '98); *Missouri Botanical Garden, St. Louis, Mo.;* Asst. Ill. State Lab. Nat. Hist., '95–'96; Instr. Bot., Cornell Univ. and Asst. Cryptg. Bot., Expt. Sta., '96–'99; Asst. Prof. Bot., Cornell, '00–'01; Physiologist, U. S. Dept. Agr., '01–'02; Prof. Bot., Univ. Mo., '02–'07; Plant Physiologist, Coll. Agr. and Expt. Sta., Cornell Univ., '07–'12; Prof. Plant Physiol. and Appl. Bot., Wash. Univ., '12—.

1910. JOHN FREDERICK DUGGAR, B. S. (Miss. Agr. Coll., '87), M. S. (do., '88); *Auburn, Ala.;* Asst. in Agr., Tex. Agr. Coll., '87–'89; Asst. Dir., S. C. Expt. Sta., '90–'92; Agr. Editor Office Expt. Stas., U. S. Dept. Agr., '93–'95; Prof. Agr., Ala. Poly. Inst., '96—; Dir. Ala. Expt. Sta., '03—.

1903. ROLLINS ADAMS EMERSON, B. S. (Univ. Nebr., '97); *Lincoln, Nebr.;* Hort. Editor Office Expt. Stas., U. S. Dept. Agr., '97–'98; Asst. Prof. Hort., Univ. Nebr., '99–'04; Prof. Hort., do., '05—; Hort. Expt. Sta., '98—.

1899. DAVID GRANDISON FAIRCHILD, B. S. (Kans. State Coll., '88), M. S. (do., '93); *Washington, D. C.;* Naples Zool. Sta., '93; Breslau and Berlin, '94; Bonn, '95; Buitenzorg Botanic Gardens, '96; Asst. Path. U. S. Dept. Agr., '89–'92; Special Agt. in charge Seed and Plant Introduction, '97–'98; Agr. Explorer, '98–'03; in charge Foreign Seed and Plant Introduction, U. S. Dept. Agr., '03—.

1880. WILLIAM GIBSON FARLOW, A. B. (Harvard Univ., '66), M. D. (do., '70), LL. D. (do., '96; Univ. Glasgow, '01; Univ. Wis., '04); *24 Quincy St., Cambridge, Mass.;* Asst. Prof. Bot., Harvard Univ., '74–'79; Prof. Cryptg. Bot., do., '79—.

1909. EDWARD HOLYOKE FARRINGTON, B. S. (Univ. Me., '81), M. S. (Yale, '82); *Madison, Wis.;* Chem., Conn. State Expt. Sta., '83–'89; do., Ill. Expt. Sta., '90–'94; Assoc. in Dairy Husb., Wis. Univ. and Expt. Sta., '94–'00; Prof. Dairy Husb., do , '00—.

1890. BERNHARD EDWARD FERNOW (Münden Forest Acad. grad., '73) LL. D. (Univ. Wis., '97; Queen's '03); *Toronto, Can.;* Chief, Div. Forestry, U. S. Dept. Agr., '86–'98; Dir. N. Y. State Coll. of Forestry, '98–'03; Lecturer Yale Forestry School, '04; Prof. of Forestry, Univ. of Toronto, '07—.

1911. MARTIN LUTHER FISHER. B. S. (Purdue Univ., '03), M. S. (Univ. Wis., '11); *Lafayette, Ind.;*Asst. in Agr., Purdue Univ., '03–'04; Instr. Agr., do., '04–'06; Asst. Prof. Agron., do.,'06–'08; Assoc. Prof. Agron., do., '08–'10; Prof. Crop Prod., do., '10—; Asst. Agr., Indiana Expt. Sta., '03–'10; Assoc. in Crops, do., '10—

1910. ERNEST BROWNING FORBES, B. Sc. (Univ. Ill., '97), B. S. Agr. do., '02), Ph. D. (Univ. Mo., '08); *Wooster, Ohio;* Zool. Asst., Ill. Biol. Sta., '94–'96; Asst. to State Ento. of Minn., '97–'98; Acting State Ento. Minn., '01; Asst. in An. Husb., Ill. Expt. Sta., '01–'02; Instr. An. Husb., Univ. Ill., '02–'03; Asst. Prof. An. Husb., Univ. Mo., '03–'07; Chief in Nutrition, Ohio Expt. Sta., '07—.

1908. STEPHEN ALFRED FORBES, Ph. D. (Ind. Univ., '84), LL. D. (Univ. Ill., '05), *Urbana, Ill.;* Prof. Zool., Univ. Ill., '84–'09; State Ento. Ill., '82—; Dir. Ill. State Lab. of Nat. Hist., 77—; Dean Coll. of Sci., Univ. of Ill., '88—.

1911. George Stronach Fraps, B. S. (N. C. Agr. Coll., '96), Ph. D. (Johns Hopkins Univ., '99); *College Station, Tex.;* Asst. Prof. Chem., N. C. Agr. Coll., and Asst. Chem. in Expt. Sta., '99–'03; Asst. Chem., Tex. Expt. Sta., '03–'04; Assoc. Chem., do., '04–'05, Chem., do., '05—; Assoc. Prof. Chem., Tex. Agr. Coll., '03–'05; Acting Prof., do., '05–'06; Assoc. Prof. Agr. Chem., do., '06—; State Chem., '06—.

1888. William Frear, A. B. (Bucknell Univ., '81), Ph. D. (Ill. Wesleyan Univ., '83); *State College, Pa.;* Asst. Sci., Bucknell Univ., '81–'83; Asst. Chem. U. S. Dept. Agr., '83–'85; Prof. Agr. Chem., Pa. State Coll., '85—; Vice Dir. and Chem., Pa. Expt. Sta., '87—.

1908. Beverly Thomas Galloway, B. S. (Univ. Mo., '84), LL. D. (do.,' 02); *Washington, D. C.;* Asst. Hort., Univ. Mo., '84–'87; Asst. Path., U. S. Dept. Agr., '87–'88; Path. and Chief, Div. Veg. Path. and Physiol., do., '88–'01; Chief Bur. Plant Indus., do., '01–'13; Asst. Sec. of Agr., '13—.

1894. Harrison Garman, *Lexington, Ky.;* Asst. State Lab. Nat. Hist., Ill., '83–'89; Asst. Prof. Zool., Univ. Ill., '85–'89; Ento. and Bot., Ky. Expt. Sta., '89—; State Ento., Ky. '97—.

1894. Charles Christian Georgeson, B. S. (Mich. Agr. Coll., '78), M. S. (do.,' 82); *Sitka, Alaska;* Asst. Ed. of *Rural New Yorker*, '78–'80; Prof. Agr. and Hort., Tex. A. and M. Coll., '80–'83; Prof. Agr., Coll. of Agr., Imperial Univ., Tokyo, Japan, '86–'89; Prof. Agr., Kans. State Agr. Coll., '90–'97; Special Agt. U. S. Dept. Agr., Dairy Industry, Denmark, '93; Asst. Agrostologist, U. S. Dept. Agr., '97–'98; Special Agt. in charge Alaska Expt. Sta., do., '98—.

1893. Clarence Preston Gillette, B. S. (Mich. Agr. Coll., '84), M. S. (do., '88); *Fort Collins, Col.;* Asst. Zool., Mich. Agr. Coll., '87–'88; Ento. Iowa Expt. Sta., '88–'91; Prof. Zool. and Ento., Col. Agr. Coll. and Ento. Expt. Sta., do., '91—; Dir. Expt. Sta., do., '10—.

1911. Arthur Goss, B. S. (Purdue Univ., '88), M. S. (do., '95); *Lafayette, Ind.;* Asst. Chem., Ind. Expt. Sta., '88–'92; Asst., Ind. Weather Serv., '89–'92; Prof. Chem., N. Mex. Agr. Coll., and Chem. in Expt. Sta., '92–'03; Vice-Dir., N. Mex. Expt Sta., '95–'00; Dir., Ind. Expt. Sta., '03—.

1909. Harry Sands Grindley, B. S. (Univ. Ill., '88), Sc. D. (Harvard, '94); *Urbana, Ill.;* Asst. Chem., Univ. Ill., '88–'92; Asst. Chem., Harvard, '92–'93; Fellow Harvard, '93–'94; Instr. Chem., Univ. Ill., '94–'95; Asst. Prof. Chem., do., '95–'99; Assoc. Prof. Chem., do., '99–'04; Prof. and Dir. Chem. Lab., do., '04–'07; Prof. An. Chem., do., and Chief An. Chem., Expt. Sta., '07—.

1909. Theophilus L. Haecker, *University Farm, St. Paul, Minn.;* in charge Dairy Husb., Minn. Univ. and Expt. Sta., '92–'07; Prof. Dairy Husb. and An. Nutrition, do., '07–'09; Prof. Dairying, An. Husb. and An. Nutrition, do., '10—.

1880. BYRON DAVID HALSTED, B. S. (Mich. Agr. Coll., '71), M. S. (do., '74), Sc. D. (Harvard Univ., '78); *New Brunswick, N. J.;* Ed. *American Agriculturist,* '79–'85; Prof. Bot., Iowa State Coll., '85–'89; Prof. Bot. and Hort., Rutgers Coll., '89–'10; Bot., N. J. Expt. Sta., '89—.

1902. NIELS EBBENSEN HANSEN, B. S. (Iowa State Coll., '87), M. S. (do., '95); *Brookings, S. Dak.;* Asst. Prof. Hort., Iowa State Coll., '91–'95; Prof. Hort. and Forestry, S. Dak. Agr. Coll., and Hort., Expt. Sta., '95—.

1910. JOSEPH NELSON HARPER, B. S. (Miss. Agr. Coll., '95), M. A. (Ky. Agr. Coll., '06); *Clemson College, S. C.;* Dairy Husb., Miss. Expt. Sta., '95; Dairy Husb., Ky. Expt. Sta., '96–'98; Agriculturist, do., '98–'05; Dir. and Agron., S.C. Expt. Sta., '06—.

1911. EDWIN BRET HART, B. S. (Univ. Mich., '97); *Madison, Wis.;* Asst. Chem., N. Y. Expt. Sta., '97–'00; Assoc. Chem., do., '06; Prof. Agr. Chem., Univ. Wis., and Chem., Wis. Expt. Sta., '06—.

1910. BURT LAWS HARTWELL, B. S. (Mass. Agr. Coll. and Boston Univ., '89), M. S. (Mass. Agr. Coll., '00), Ph. D. (Univ. Pa., '03); *Kingston, R. I.;* Asst. Chem., Mass. Expt. Sta., '89–'91; Asst. Chem., R. I. Expt. Sta., '91–'03; Assoc. Chem., do., '03–'07; Chem., do., '07—; Prof. Agr. Chem., R. I. State Coll., '08—; Dir., R. I. Expt. Sta., '13—.

1905. WILLET MARTIN HAYS, B. Agr. (Iowa State Coll., '85), M. Agr. (do., '86); *Washington, D. C.;* Asst. Iowa Agr. Coll., '86; Assoc. Ed., *Prairie Farmer,* '87; Asst. in Agr., Iowa Agr. Coll., '88–'89; Prof. Agr. and Agriculturist, Minn. Agr. Coll. and Expt. Sta., '90–'91; Prof. Agr. and Agriculturist, N. Dak. Agr. Coll. and Expt. Sta., '92–'93; Prof. Agr. and Agriculturist, Minn. Agr. Coll. and Expt. Sta., '93–'04; Asst. Sec. of Agr., U. S. Dept. Agr., '04—'13.

1911. HARRY HAYWARD, B. S. (Cornell Univ., '94), M. S. (do., '01); *Newark, Del.;* Asst. Prof. Dairy Husb., Pa. State Coll., '97–'02; Assoc. Prof. An. and Dairy Husb., N. H. Agr. Coll., '02–'03; Asst. Chief Dairy Div., U. S. Dept. Agr., '03; Dir. Agr. Dept., Mount Hermon School, '03–'06; Dean Agr. Dept., Del. Coll., and Dir. Del. Expt. Sta., '06—.

1909. WILLIAM PARKER HEADDEN, A. B. (Dickinson, '72), A. M. (do., '75), Ph. D. (Univ. Giessen, '74); *Fort Collins, Col.;* Asst., Univ. Pa., '74–'76; Prof. Chem., Md. Agr. Coll., '80–'84; do., Univ. Denver, '84–'89; do., S. Dak. School of Mines, '89–91; Dean, do., '92–'93; Prof. Chem. and Geol., Col. Agr. Coll., and Chem., Expt. Sta., '93—.

1909. ULYSSES PRENTISS HEDRICK, B. S. (Mich. Agr. Coll., '93), M. S. (do., '95); *Geneva, N. Y.;* Asst. Hort., Mich. Agr. Coll., '93–95; Prof. Bot. and Hort., Ore. Agr. Coll., and Hort. Expt. Sta., '95–'97; Prof. Bot. and Hort., and Hort., Expt. Sta., Utah, '97–'99; Prof. Hort., Mich. Agr. Coll., '99–'05; Hort., N. Y. Expt. Sta., '05—.

1880. EUGENE WALDEMAR HILGARD, Ph. D. (Heidelberg, '53), LL. D. (Columbia Univ., '87); *Berkeley, Cal.;* State Geol., Miss., '58–'72; Prof. Chem., Univ. Miss., '66–'73; Prof. Geol. and Nat. Hist., Univ. Mich., '73–'75; Prof. Agr., Univ. Cal., and Agriculturist, Expt. Sta., '75–'06; Dir. Cal. Expt. Sta., '88–'06; Prof. Emeritus, '06—.

1905. JOSEPH LAWRENCE HILLS. B. Sc. (Mass. Agr. Coll. and Boston Univ., '81), D. Sc. (honorary, '03, Rutgers Coll.); *Burlington, Vt.;* Asst. Chem., Mass. Expt. Sta., '82–'83; Asst. Chem., N. J. Expt. Sta., '84–'85; Chem. Phos. Mining Co. Ltd., Beaufort, S. C., '85–'88; Chem., Vt. Expt. Sta., '88–'98; Dir., do., '98—; Prof. Agr. Chem., Univ. Vt. '93—; Dean, Dept. Agr., do., '98—.

1911. CYRIL GEORGE HOPKINS, B. S. (S. Dak. Agr. Coll., '90), M. S. (Cornell Univ., '94), Ph. D. (do., '98); *Urbana, Ill.;* Asst. Chem., S. Dak. Agr. Coll. and Expt. Sta., '90–'92; do., Cornell Univ., '92–'93; Acting Prof. Pharm., S. Dak. Agr. Coll., '93–'94; Chem., Ill. Expt. Sta., '94—; Prof. Agron., Univ. Ill., '00—.

1889. LELAND OSSIAN HOWARD, B. S. (Cornell Univ., '77), M. S. (do., '86), Ph. D. (Georgetown Univ., '96); *Washington, D. C.;* Asst. Ento., U. S. Dept. Agr., '78–'94; Chief Ento., do., '94—; Perm. Sec., A. A. A. S., '98—.

1912. WALTER LAFAYETTE HOWARD, B. Agr., B. S. (Univ. Mo., '01), M. S. (do., '03), Ph. D. (Univ. Halle-Wittenberg, '06); *Columbia, Mo.;* Asst. in Hort., Univ. Mo., '01–'03; Instr., do., '03–04; Asst. Prof., do., '05–'08; Sec., Mo. State Board Hort., '08–'12; Prof. Hort., Univ. Mo., '08—.

1903. THOMAS FORSYTH HUNT, B. S. (Univ. Ill., '84), M. S. (do., '92), D. Agr. (do., '04), D. Sc. (Mich. Agr. Coll., '07); *Berkeley, Cal.;* Asst. State Ento. of Ill., '85–'86; Asst. Agr., Univ. Ill., '86–'88; Asst. Agr., Ill. Expt. Sta., '88–'91; Prof. Agr., Pa. State Coll., '91–'92; Prof. Agr., Ohio State Univ., '92–'95; Dean Coll. Agr., Ohio State Univ., '95–'03; Prof. Agron., Cornell Univ., and Agron., Expt. Sta., '03–'06; Dean Coll. Agr., and Dir. Agr. Expt. Sta., Pa. State Coll., '06–'12; Dean Coll. Agr., Univ. Cal., and Dir. Expt. Sta., '12—.

1908. WILLIAM DANIEL HURD, B. S. (Mich. Agr. Coll., '99), M. Agr. (do., '08); *Amherst, Mass.;* Instr., Lansing High School, '99–'01; Prof. Hort., Briarcliff Agr. School, '01–'03; Prof. Agr., Univ. Me., '03–'05; Acting Dean, Coll. of Agr., do., '05–'06; Dean, '06–'09; Dir. of Short Courses, Mass. Agr. Coll., '09—.

1898. HENRY CLAY IRISH, B. S. (S. Dak. Agr. Coll., '91), M. S. (Iowa State Coll., '98); *Missouri Botanical Garden, St. Louis, Mo.;* Hort. Asst., Mo. Bot. Gard., '95–'02; Supt., do '03—.

1908. MYER EDWARD JAFFA, Ph. B. (Univ. Cal., '77), M. S. (do., '96); *Berkeley, Cal.;* Asst. Chem., U. S. Census, '79–'80; Asst. Agr. Dept., Univ. Cal., '80–'81; Asst. Chem., Northern Transcontinental Surv., '81–'83; Asst. Chem., Univ. Cal., '83–'96; Asst. Prof. Agr., do., '96–'06; do., Nutrition, '06–'08; Prof. Nutrition, do., '08—.

1885. Edward Hopkins Jenkins, A. B. (Yale Univ., '72), Ph. D. (do., '79); *New Haven, Conn.*; Chem., Conn. Expt. Sta., '76–'00; Vice Dir., do., '82–'00; Dir., do., '00—; Treas., do., '01—; Dir., Storrs Expt. Sta., '12—.

1894. Whitman Howard Jordan, B. S. (Univ. Me., '75), M. S. (do., '79), D. Sc. (do., '96), LL. D. (Mich. Agr. Coll., '07); *Geneva, N. Y.;* Asst. Chem., Conn. Expt. Sta., '78–'79; Instr. Agr., Univ. Me., '79–'80; Prof. Agr. and Agr. Chem., Pa. State Coll., '81–'85; Dir., Me. Expt. Sta., '85–'96; Prof. Agr., Univ. Me., '94–'96; Dir., N. Y. Expt. Sta., '96—.

1912. John Chester Kendall, B. S. (N. H. Coll., '02); *Durham, N. H.;* Instr. in Dairy Husb., N. C. Agr. Coll., '02–'03; Asst. Prof. of Dairy Husb., do., '03–'06; State Dairy Comr., Kans., '06–'07; Prof. of Dairy Husb., Kans. Agr. Coll., '08–'10; Dir., N. H. Expt. Sta., '10—; Dir. of Ext. Work, N. H., '11—.

1909. Benjamin Wesley Kilgore, B. S. (Miss. Agr. Col., '88), M. S. (do., '90); *Raleigh, N. C.;* Asst. Chem., Miss. Agr. Coll., '88–'89; do., N. C. Expt. Sta., '89–'97; Prof. Chem., Miss. Agr. Coll. and Agr. Expt. Sta., '97–'99; State Chem., N. C., '99—; Dir., N. C. Expt. Sta., '01–'07; do., '13—.

1911. Henry Granger Knight, A. B. (Univ. Wash., Seattle, '02), A. M. (do., '04); *Laramie, Wyo.;* Asst. Chem., Univ. Wash., '00–'01; Instr., do., '01–'02; Asst. Chem., Univ. Chicago, '02–'03; Asst. Prof. Chem., Univ. Wash., '03–'04; Prof. Chem., Univ. Wyo., and State Chem., '04—; Dir., Wyo. Expt. Sta., '10—.

1889. Edwin Fremont Ladd, B. Sc. (Univ. Me., '84); *Agricultural College, N. Dak.;* Asst. Chem., N. Y. State Expt. Sta., '84–'87; Chief Chem., do., '87–'90; Prof. Chem., N. Dak. Agr. Coll. and Chem. Expt. Sta., '90—; Food Comr. and State Chem., N. Dak., '00—.

1883. William Rane Lazenby, B. Agr. (Cornell Univ., '74), M. Agr. Iowa Agr. Coll., '87); *Columbus, Ohio;* Instr. Hort., Cornell Univ., '74–'77; Asst. Prof. Hort., do., '77–'81; Prof. Hort. and Bot., Ohio State Univ., '81–'82; Dir., Ohio Expt. Sta., '82–'87; Prof. Hort. and Forestry, Ohio State Univ., '82–'09; Prof. Forestry, do., '09—.

1899. Joseph Bridgeo Lindsey, B. Sc. (Mass. Agr. Coll., '83), Ph. D. (Univ. Göttingen, '92); *Amherst, Mass.;* Asst. Chem., Mass. State Expt. Sta., '83–'85; Commercial Chem., '85–'89; Assoc. Chem., Mass. State Expt. Sta., '92–'95; Head Dept. Foods and Feeding, Hatch Expt. Sta., '95–'07; Chem., Mass. Expt. Sta., '07—; Vice Dir., do., '09—; Head Dept. Chem., Mass. Agr. Coll. and Goessmann Prof. of Agr. Chem., '11—.

1911. Frederick Bloomfield Linfield, B. S. A. (Ontario Agr. Coll., '91); *Bozeman, Mont.;* Asst. in Dairying, Ontario Agr. Coll., '92–'93; Prof. Anim. Indus. and Dairying, Utah Agr. Coll., '93–'02; Prof. Agr., Mont. Agr. Coll., '02—; Acting Dir., Mont. Expt. Sta., '03; Dir., do., '04—.

1912. Charles Bernard Lipman, B. Sc. (Rutgers Coll., '04), M. Sc. (do., '09), M. S. (Univ. Wis., '09), Ph. D. (Univ. Cal., '10); *Berkeley, Cal.;* Instr. in Soil Bact., Univ. Cal., '09–'10; Asst. Prof. Soils, do., '10–'12; Assoc. Prof. of Soils, do., and Soil Chem. and Bact., Cal. Expt. Sta., '12—.

1909. Jacob G. Lipman, B. Sc. (Rutgers, '98), A. M. (Cornell, '00), Ph. D. (do., '03); *New Brunswick, N. J.;* Asst. Chem., N. J. Expt. Sta., '98–'99; Fellow Chem., Cornell, '01; Soil Chem. and Bact., N. J. Expt. Sta., '01—; Asst. Prof. Agr., Rutgers, '06–'07; Assoc., do., '07–'10; Prof. Soil Chem. and Bact., '10—; Dir., N. J. Expt. Stas., '11—.

1911. Edward Read Lloyd, B. S. (Ala. Poly. Inst., '87), M. S. (do., '88); *Agricultural College, Miss.;* Prof. Agr., Miss. Agr. Coll., '00–'05; Dir. Farmers' Insts., do., '06–'10; Vice Dir. and Anim. Husb., Miss. Expt. Sta., '10–'12; Dir., do., '12—.

1911. Charles Alfred Lory, B. Ped. (State Normal School, Greeley, Col., '98), B. S. (Univ. Col., '01), M. S. (do., '02), LL. D. (do., '09); *Fort Collins, Col.;* Asst. in Physics, Univ. Col., '99–'02; Prin. Cripple Creek High School, '02–'04; Acting Prof. Physics, Univ. Col., '04–'05; Prof. Physics and Elect. Engin., Col. Agr. Coll., '07–'09; Pres., do., '09—.

1899. Robert Hills Loughridge, B. S. (Univ. Wis., '71), Ph. D. (do., 76); *Berkeley, Cal.;* Asst. Prof. Chem., Univ. Miss., '72–'74; Asst. State Geol., Miss., '72–'74; do., Ga., '74–'78; do., Ky., '82–'85; Prof. Agr. Chem., S. C. Coll., '85–'90; Asst. Prof. Agr. Chem. and Geol., Univ. Cal., '91–'08; Assoc. Prof., do., '08–'09; Emeritus Prof. Agr. Chem., do., '09—.

1901. Thomas Lyttleton Lyon, B. S. A. (Cornell Univ., '91), Ph. D. (Göttingen, '94); *Ithaca, N. Y.;* Instr. Chem., Univ. Nebr., '91–'93; Asst. Chem., Nebr. Expt. Sta., '94–'95; Assoc. Prof. Agr., Univ. Nebr., '95–'99; Prof. Agr., do., and Assoc. Dir. Expt. Sta., '99–'06; Prof. Expt. Agron., Cornell Univ. and Expt. Sta., '06—.

1911. Arthur Gillett McCall, B. S. Agr. (Ohio State Univ., '00); *Columbus, Ohio;* Asst., Bur. Soils, U. S. Dept. Agr., '00–'04; Asst. Prof. Agron., Ohio State Univ., '04–'05; Assoc. Prof. Agron., do., '05–'06; Prof. Agron., do., '06—.

1911. Charles Edward Marshall, Ph. B. (Univ. Mich., '95), Ph. D. (do., '02); *Amherst, Mass.;* Asst. Bact., Univ. Mich., '93–'96; do., Mich. Expt. Sta., '96–'98; Bact. and Hygienist, do., '98–'12; Sci. and Vice Dir., do., '08–'12; Prof. Bact. and Hyg., Mich. Agr. Coll., '03–'12; Dir. Graduate School and Prof. of Microbiol., Mass. Agr. Coll., '12—.

1911. Frederick Rupert Marshall, B. S. Agr. (Ontario Agr. Col. '99), B. S. A. (Iowa State Coll., '00); *Davis, Cal.;* Asst. Prof. Anim. Husb., Iowa State Coll., '01–'03; Prof. Anim. Husb., Tex. Agr. Coll., '03–'07; Prof. Anim. Husb., Ohio State Univ., '07–'12; Prof. Anim. Indus., Univ. Cal., and Anim. Husb., Cal. Expt. Sta., '12—.

1911. DAVID WILLIAM MAY, B. Agr. (Univ. Mo., '94), M. Agr. (do., '96); *Mayaguez, P. R.;* Asst. Agr., Missouri Expt. Sta., '97; Sci. Asst. Office Expt. Stas., U. S. Dept. Agr., '00–'02; Anim. Husb., Ky. Expt. Sta., '02–'04; Special Agt. in Charge, P.R. Expt. Sta., '04—.

1905. LUCIUS HERBERT MERRILL, B. S. (Univ. Me., '83), D. Sc. (honorary, do., '08); *Orono, Me.;* Chem., Me. Expt. Sta., '86–'08; Prof. Biol. Chem., Univ. Me., '98–'07; Prof. Biol. and Agr. Chem., do., '07—.

1909. MERRITT FINLEY MILLER, B. S. Agr. (Ohio State Univ., '00), M. S. A. (Cornell Univ., '01); *Columbia, Mo.;* Asst. Bur. Soils, U. S. Dept. Agr., '01–'02; Instr. Agron., Ohio State Univ., '02–'03; Asst. Prof., do., '03–'04; Prof. Agron., and Agron., Univ. Mo. and Expt. Sta., '04—.

1910. GEORGE THOMAS MOORE, B. S. (Wabash Coll., '94), A. B. (Harvard Univ., '95), A. M. (do., '96), Ph.D. (do., '00); *Missouri Botanical Garden, St. Louis, Mo.;* in charge Bot. Dept., Dartmouth Coll., '99–'01; Physiol. and Algologist, Bur. Plant Indus., U. S. Dept. Agr., '01–'02; in charge Lab. Plant Physiol., do., '02–'05; Prof. Plant Physiol. and Applied Bot., Shaw School of Bot., Mo. Bot. Gard., '09–'12; Dir., Mo. Bot. Gard., '12—.

1900. JOHN HARCOURT ALEXANDER MORGAN, B. S. A. (Univ. Toronto, '89); *Knoxville, Tenn.;* Prof. Ento. and Hort., La. State Univ., '89–'93; Prof. Zool. and Ento., do., '93–'04; Ento., La. Expt. Stas., '89–'04; Dir. Gulf Biol. Sta., '99–'05; Dir. Tenn. Expt. Sta., '05—.

1911. FRED WINSLOW MORSE, B. S. (Worcester, '87), M. S. (do., '00); *Amherst, Mass.;* Asst. Chem., Mass. Expt. Sta., '87–'88; do., N. H. Expt. Sta., '88–'89; Chem., do., '89–'09; Vice Dir., do., '96–'09; Prof. Chem., N. H. Agr. Coll., '90–'09; Research Chem., Mass. Expt. Sta., '10—.

1912. WARNER JACKSON MORSE, B. S. (Univ. Vt., '98), M. S. (do., '03), Ph. D. (Univ. Wis., '12); *Orono, Me.;* Teacher Nat. Sci., Montpelier Seminary, '99–'01; Asst. Bot., Vt. Expt. Sta., '01–'06; Instr. Bot., do., '01–'05; Asst. Prof. Bact., do., '05–'06; Plant Path., Me. Expt. Sta., '06—.

1909. FREDERICK BLACKMAR MUMFORD, B. S. (Mich. Agr. Coll., '91), M. S. (do., '93); *Columbia, Mo.;* Asst. Mich. Expt. Sta., '91–'95; Asst. Prof. Agr., Mich. Agr. Coll., '93–'95; Prof. Agr., Univ. Mo., '95–'04; Acting Dean Coll. Agr., Univ. Mo., and Acting Dir., Mo. Expt. Sta., '03–'05; Prof. An. Husb., Univ. Mo., '04—; in charge An. Husb. Dept., Mo. Expt. Sta., '06–; Dean Agr. and Dir. Expt. Sta., '09—.

1901. HERBERT WINDSOR MUMFORD, B. S. (Mich. Agr. Coll., '91); *Urbana, Ill.;* Instr., Mich. Agr. Coll., and Asst., Expt. Sta., '95–'96; Asst. Prof. Agr. and An. Husb., do., '96–'99; Prof. Agr., do., '99–'01; Prof. An. Husb., Univ. Ill., and Chief in An. Husb., Ill. Expt. Sta., '01—.

1893. HERBERT OSBORN, B. S. (Iowa State Coll., '79), M. S. (do., '80); *Columbus, Ohio;* Asst. Zool. and Ento., Iowa State Coll., '79–'83; Asst. Prof., do., '83–'85; Prof., do., '85–'98; Prof. Zool. and Ento., Ohio State Univ., '98—.

1893. LOUIS HERMAN PAMMEL, B. Agr. (Univ. Wis., '85), M. S. (do., '89), Ph. D. (Wash. Univ., '99); *Ames, Iowa;* Asst., Shaw School of Bot., '86–'89; Tex. Agr. Expt. Sta., '89; Prof. Bot., Iowa State Coll., '89—; Bot. Iowa Expt. Sta., '92—.

1893. HENRY JACOB PATTERSON, B. S. (Pa. State Coll., '86); *College Park, Md.;* Asst. Chem., Pa. Expt. Sta., '86–'88; Chem., Md. Expt. Sta., '88–'98; Dir. and Chem., do., '98—.

1910. RAYMOND PEARL, A. B. (Dartmouth Coll., '99), Ph. D. (Univ. Mich., '02); *Orono, Me.;* Asst. Zool., Univ. Mich., '99–'02; Instr. Zool., do., '02–'06; Instr. Zool., Univ. Penn., '06–'07; Biol. and Head Dept. Biol., Me. Expt. Sta., '07—; Assoc. Ed. *Zool. Jahresber*, '06–'08, *Biometrika*, '06–'10, *Zentbl. Allg. u. Expt. Biol.*, '10—.

1909. RAYMOND ALLEN PEARSON, B. S. A. (Cornell Univ., '94), M. S.A. (do., '99); *Ames, Iowa;* Asst. Chief Dairy Div., U. S. Dept. Agr., '95–'02; Mgr. Walker-Gordon Lab. Co., N. Y. and Phila., '02–'03; Prof. Dairy Ind., Cornell Univ., '03–'07; N. Y. Comr. Agr., '07–'12; Pres. Iowa State Coll., '12—.

1910. WILLIAM ROBERT PERKINS, B. S. (Miss. Agr. Coll., '91); M. S. (do., '94); *Deeson, Miss.;* Asst. State Chem., Miss., '91–'94; Chem., Miss. Expt. Sta., '94–'06; Asst. Prof. Agr., Miss. Agr. Coll., '06; Agron., Miss. Expt. Sta., '07–'10; Dir. Agr. Dept., and Prof. Agron., Clemson Coll., '10–'11; Supt. Syndicate Farm, Deeson, Miss., '11—.

1909. CHARLES VANCOUVER PIPER, B. S. (Univ. Wash., '85), M. S. (do., '92; Harvard, '00); *Washington, D. C.;* Prof. Ento., Wash. State Coll., '92–'93; Prof. Bot. and Zool., do., and Bot. and Ento., Expt. Sta., '93–'03; Syst. Agrostologist, U. S. Dept. Agr., '03–'04; Agrostologist, do., '05—.

1890. CHARLES SUMNER PLUMB, B. S. (Mass. Agr. Coll., '82); *Columbus, Ohio;* Asst. Ed. *Rural New Yorker*, '83–'84; First Asst., N. Y. Expt. Sta., '84–'87; Prof. Agr., Univ. Tenn., and Asst. Dir., Expt. Sta., '87–'90; Prof. Agr. Sci., Purdue Univ., '90–'94; Prof. An. Ind. and Dairying, do., '94–'00; Prof. An. Ind., do., '00–'02; Vice Dir., Ind. Expt. Sta., '90–'91; Dir., do., '91–'02; Prof. An. Ind., Ohio State Univ., '02—.

1884. FRANK WILLIAM RANE, B. Agr. (Ohio State Univ., '91), M. Sc. (Cornell Univ., '92); *State House, Boston, Mass;* Hort. and Microscopist, W. Va. Expt. Sta., '92–'95; Prof. Agr. and Hort., W. Va. Univ., '93–'95; Prof. Agr. and Hort., N. H. Coll., '95–'98; Prof. Hort., do., '98–'00; Prof. Forestry and Hort., do., '00–'06; State Forester, Mass., '06—.

1881. ISAAC PHILLIPS ROBERTS, M. Agr. (Iowa State Coll., '75); *Palo Alto, Cal.;* Prof. Agr. and Dean Agr., Cornell Univ., '73–'94;

Dir. Cornell Expt. Sta., '88–'03; Dir. Col. Agr., '94–'03; Prof. Emeritus and lecturer, '03—.

1893. JAMES WILSON ROBERTSON, LL. D. (Toronto Univ., and Queen's Univ., '03; Univ. New Brunswick, '04); *Box 540, Ottawa, Can.;* Prof. Dairying, Ontario Agr. Coll., '86–'90; Dairy Comr. Canada, '90–'95; Comr. Agr. and Dairying, '95–'04; Prin., MacDonald Coll., '05–'09; Chairman Royal Com. on Indus. Training and Tech. Ed., '10—.

1909. PETER HENRY ROLFS, B. S., M. S. (Iowa State Coll., '91); *Gainesville, Fla.;* Asst. Bot., Iowa State Coll., '91; Ento. and Bot., Fla. Expt. Sta., '92–'98; Bot. and Hort., do., '98–'99; Bot. and Bact., S. C. Expt. Sta., '99–'01; Plant Path. in charge Sub-Trop. Lab., U. S. Dept. Agr., Miami, Fla., '01–'06; Dir., Fla. Expt. Sta., '06—; State Supt. Farmers' Institutes, '07—.

1911. GEORGE MCCULLOUGH ROMMEL, B. S. (Iowa Wesleyan Univ., '97), B. S. A. (Iowa State Coll., '99); *Washington, D. C.;* Expert in Anim. Husb., Bur. Anim. Indus., U. S. Dept. Agr., '01–'05; Anim. Husb., do., '05–'09; Chief, Anim. Husb. Div., do., '10—.

1909. HARRY LUMAN RUSSELL, B. S. (Univ. Wis., '88), M. S. (do., '90), Ph. D. (Johns Hopkins, '92); *Madison, Wis.;* Fellow Univ. Wis., '88–'90; Fellow Univ. Chicago, '92–'93; Asst. Prof. Bact., Univ. Wis., '93–'96; Prof., do., '96–'97; Bact., Wis. Expt. Sta., '93–'97; Dir. State Hygienic Lab., '03–'07; Dean Coll. of Agr. and Dir. Expt. Sta., Univ. Wis., '07—.

1912. WALTER GEORGE SACKETT, B. S. (Univ. Chicago, '02); *Fort Collins, Col.;* Prof. Nat. Sci., Meredith Coll., '02–'04; Special Agt., U. S. Dept. Agr., '04; Instr. Bact. and Hyg., Mich. Agr. Coll., '04–'06; Asst. Prof. Bact. and Hyg., do., and Asst. Bact., Mich. Expt. Sta., '06–'08; Bact., Col. Expt. Sta., '08—.

1908. EZRA DWIGHT SANDERSON, B. S. (Mich. Agr. Coll., '97), B. S. Agr. (Cornell, '98); *Morgantown, W. Va.;* Asst. State Ento. Md., '98–'99; Ento., Del. Expt. Sta., and Assoc. Prof. Zool., Del. Coll., '99–'02; State Ento. Tex., and Prof. Ento., Tex. A. and M. Coll., '02–'04; Ento., N. H. Expt. Sta., and Prof. Ento. and Zool., N. H. Coll., '04–'09; Dir. N. H. Expt. Sta., '07–'09; Dean Coll. Agr., W. Va. Univ., '10—; Dir., W. Va. Expt. Sta., '12—.

1910. ROBERT SIDEY SHAW, B. S. (Ontario Agr. Coll., '93); *East Lanssing, Mich.;* Asst. Agr., Mont. Agr. Coll. and Expt. Sta., '97–'02; Prof. Agr., Mich. Agr. Coll., '02–'08; Dean Agr., do., and Dir. Expt. Sta., '08—.

1893. THOMAS SHAW, *Buffalo, Mont.;* Prof. Agr., Ontario Agr. Coll., '88–'93; Prof. An. Husb., Minn. Coll. Agr., '93–'03; Ed. *Farmer*, '03–'08; Northwest Ed. Orange Judd Publications, '08—.

1898. JOHN HENRY SHEPPERD, B. Agr. (Iowa State Coll., '91). M. S. A. (Univ. Wis., '93); *Agricultural College, N. Dak.;* Ed. Staff *Orange Judd Farmer*, '93; Prof. Agr., N. Dak. Agr. Coll., and

Agriculturist Expt. Sta., '93–'04; Dean and Vice Dir., do., '04—.

1909. John Harrison Skinner, B. S. (Purdue Univ., '97); *Lafayette, Ind.;* Asst. Agr., Ind. Expt. Sta., '99–'01; Instr. An. Husb., Univ. Ill., '01–'02; Assoc. Prof. An. Husb., Purdue Univ., '02–'06; Prof., do., '06; Dean Agr. Dept., Purdue Univ., '07—.

1907. Clinton DeWitt Smith, M. S. (Cornell Univ., '75); *Trumansburg, N. Y.;* Dir. Ark. Expt. Sta., '90; Dir. Minn. Sta., and Prof. Dairy Husb., Univ. Minn., '90–'93; Dir. Mich. Expt. Sta. and Prof. Agr., '93–'08; Dir. and Dean Spec. Course, Mich. Agr. Coll., '99–'08; Dir. Escola Agricola Practica, '08–'12.

1907. Howard Remus Smith, B. Sc. (Mich. Agr. Coll., '95); *University Farm, St. Paul, Minn.;* Teacher, Tilford Collegiate Acad. and Rock Island High School, '95–'09; Acting Prof. Agr., Univ. Mo., '00–'01; Asst. Prof. An. Husb., Univ. Nebr., '01; Assoc. Prof., do., '02; Prof., do., '03–'12; Anim. Husb., Univ. Minn., '12—.

1899. Harry Snyder, B. S. (Cornell Univ., '89); *St. Anthony Park, St. Paul, Minn.;* Asst. Chem., Cornell Univ. Expt. Sta., '90–'91; Asst. Instr. Qual. Anal., do., '89–'90; Prof. Agr. Chem., Univ. Minn., and Chem., Expt. Sta., '91–'09; Chem., Russell Miller Milling Co., '09—.

1909. Andrew McNairn Soule, B. S. (Univ. Toronto, '93), Sc. D. (honorary, Univ. Ga., '10); *Athens, Ga.;* Asst. Dir., Mo. Expt. Sta., '94; Asst. Prof. Agr. and Asst. Agriculturist, Tex. Agr. Coll. and Expt. Sta., '94–'99; Dir. Tenn. Expt. Sta. and Chairman Agr. Faculty, Univ. Tenn., '99–'04; Dean of Agr. and Dir. Expt. Sta., Va. Poly. Inst., '04–'07; Pres. Coll. Agr., Univ. Ga., '07—.

1903. William Jasper Spillman, B. S. (Mo. State Univ., '86), M. S. (do., '89), Sc. D. (do., '10); *Washington, D. C.;* Prof. Sci., Mo. State Normal, '87–'89; Prof. Sci., Vincennes Univ., '89–'91; Prof. Sci., Ore. State Normal, '91–'94; Prof. Agr., State Coll. Wash., '94–'01; Agrostologist, U. S. Dept. Agr., '01'–04; Agriculturist in charge Farm Management, do., '04—.

1911. Frank Lincoln Stevens, B. L. (Hobart, '91), B. S. (Rutgers Coll., '93), M. S. (do., '97); Ph. D. (Univ. Chicago, '00); *Mayaguez, P. R.;* Teacher of Sci., Racine Coll., '93–'94; do., Columbus, O., High School, '94–'97; Instr. in Biol., N. C. Agr. Coll., '00–'02; Prof. Bot. and Veg. Path., do., '03–'11; Biol., N. C. Expt. Sta., '03–'11; Dean, P. R. Coll. Agr., '12—.

1908. William Alton Taylor, B. S. (Mich. Agr. Coll., '88); *Washington, D. C.;* Asst. Pomol., U. S. Dept. Agr., '91–'01; Pomol. in charge Field Investigations, '01–'10; Asst. Chief, Bur. Plant Indus., '11–'13; Chief, do., '13—.

1911. Roscoe Wilfred Thatcher, B. Sc. (Univ. Nebr., '98), M. A. (do., '01); *Pullman, Wash.;* Asst. Chem., Nebr. Expt. Sta., '99–'01; Asst. Chem., Wash. Expt. Sta., '01–'03; Chem., do.,

'03–'12; Asst. Prof. Chem., State Coll. Wash., '04–'06; Assoc. Prof., do., '06–'10; Prof. Agr. Chem. and Head of Dept. Agr., do., '10—; Dir. Wash. Expt. Sta., '07—.

1907. CHARLES EMBREE THORNE, M. Agr. (Ohio State Univ., '90) *Wooster, Ohio;* Dir. Ohio Expt. Sta., '87—.

1910. EDWARD GAIGE TITUS, B. S. (Col. Agr. Coll., '99); M. S. (do., '01), D. Sc. (Harvard, '11); *Logan, Utah;* Asst. Dept. Zool. and Ento., Col. Agr. Coll., '00–'01; Field Asst. State Ento., Ill., '01–'03; Spec. Agt., Bur. Ento., U. S. Dept. Agr., '03–'07; Prof. Zool. and Ento., Utah Agr. Coll. and Ento., Expt. Sta., '07—.

1901. CHARLES ORRIN TOWNSEND, B. S. (Univ. Mich., '88); M. S. (do., '91), Ph. D., (Leipsic, '97); *Garden City, Kans.;* Prof. St. Johns Coll., Md.; '88–'91; Prof. Sci., Wesleyan Coll., Ga., '91–'95; Instr. Bot. Barnard Coll., '98; Prof. Bot., Md. Agr. Coll. and State Plant Path. Md., '98–'01; Path. Bur. Plant Indus., U. S. Dept. Agr., '01–'10; do., '12—; Consulting Agr., U. S. Sugar and Land Co., '10–'12.

1881. SAMUEL MILLS TRACY, B. A. (Mich. Agr. Coll., '68), M. S. (do., '76); *Biloxi, Miss.;* Asst. Prof. Agr., Mo. State Univ., '77–'80; Prof. Bot. and Hort., do., '80–'87; Dir. Miss. Expt. Sta., '87–'97; Spec. Agt. U. S. Dept. Agr., '97—.

1908. WILLIAM W. TRACY, Sr., B. S. (Mich. Agr. Coll., '67), M. S. (do., '70), D. Sc. (honorary, do., '07); *Washington, D. C.;* Prof. Hort., Mich. Agr. Col., '70–'72; Supt. of Testing Gardens, U. S. Dept. Agr., '02—.

1894. WILLIAM TRELEASE, B. S. (Cornell, '80), D. Sc. (Harvard, '84), LL. D. (Wis., '02; Mo., '03; Wash. Univ., '07); *St. Louis, Mo.;* Prof. Bot., Univ. Wis., '83–'85; Engelmann Prof. Bot. and Dir. Shaw School Bot., Wash. Univ., '85—; Dir. Mo. Bot. Gard., '89–'12; Research Work, '12—.

1907. ALFRED CHARLES TRUE, B. A. (Wesleyan Univ., '73), M. A. (do, '76), Ph. D. (Erskine Coll., S. C., '86); D. Sc. (Wesleyan Univ., '06); *Washington, D. C.;* Prin. High School, Essex, N.Y., '73–'75; Instr. State Normal School, Westfield, Mass., '75–'82; Grad. Stud., Harvard Univ., '82–'84; Instr., Wesleyan Univ., '84–'88; Ed., U. S. Office Ext. Stas., '88–'91; Asst. Dir., do., '91–'93; Dir., do. '93—.

1908. ALFRED VIVIAN, Ph. G. (Univ. Wis., '94); *Columbus, Ohio;* Instr. Phar., Univ. Wis., '94–'95; Asst. Agr. Chem., do., '95–'97; Instr., do., and Asst. Chem., Expt. Sta., '97–'02; Assoc. Prof. Agr. Chem., Ohio State Univ., '02–'05; Prof. Agr. Chem., do., '05—.

1893. HENRY JACKSON WATERS, B. Agr. (Univ. Mo. '86); *Manhattan, Kans.;* Asst. Agr., Mo. Expt. Sta., '87–'91; Prof. Agr., Pa. State Coll., '92–'95; Dean Coll. Agr. and Dir. Expt. Sta., Univ. Mo., '96–'09; Pres., Kans. State Agr. Coll., '09—.

1910. Herbert John Webber, B. Sc. (Univ. Nebr., '89); M. A. (do. '90), Ph. D. (Wash. Univ., St. Louis, '00); *Riverside, Cal.;* Asst. in Bot., Univ. Nebr., '89–'90; Asst., Shaw School of Bot., '90–'92; Physiol., U. S. Dept. Agr., '92–'97; in charge Plant Breeding Lab., do., '97–'07; Prof. Expt. Plant Breeding, Cornell Univ., '07–'12; Dir., Citrus Expt. Sta., and Dean, Grad. School Trop. Agr., Univ. Cal., '13—.

1889. Clarence Moore Weed, B. S. (Mich. Agr. Coll., '83), M. S. (do., '84), D. Sc. (Ohio State Univ., '89); *Lowell, Mass.;* Asst. State Ento., Ill., '86–'88; Ento., Ohio Expt. Sta., '88–'91; Prof. Zool. and Ento., N. H. Coll., and Ento., Expt. Sta., '91–'04; Nature Study Work, State Normal School, Lowell, Mass., '04—.

1896. Julius Buell Weems, B. Sc. (Md. Agr. Coll., '88), Ph. D. (Clark Univ., '94); *South Boston, Va.;* Instr. Chem. and Math., Md. Agr. Coll., '88–'89; Con. Chem., do., '91–'92; Prof. Agr. Chem. and Chem. Expt. Sta., Iowa State Coll., '95–'04; Industrial Chem., '04—.

1904. Homer Jay Wheeler, B. Sc. (Mass. Agr. Coll. and Boston Univ., '83), Ph. D. (Univ. Göttingen, '89), D. Sc. (Brown, '11); *92 State St., Boston, Mass.;* Asst. Chem., Mass. Expt. Sta., '83–'87; Chem., R. I. Expt. Sta., '89–'08; Prof. Geol., R. I. Coll., '89–'12; Prof. Agr. Chem., do., '03–'10; Acting Pres., do., '02–'03; Dir. Expt. Sta., do., '01–'12, Agron., do., '05–'12; Expert, Amer. Agr. Chem. Co., '12—.

1889. Milton Whitney, *Washington, D. C.;* Asst. Chem., Conn. Expt. Sta., '83; Supt. Expt. Farm, N. C. Expt. Sta., '86–'88; Prof. Agr., S. C. Coll., and Vice Dir. Expt. Sta., '88–'91; Soil Physicist, Md. Expt. Sta., '91–'94; Prof. Soil Physics, Md. Agr. Coll., '94–'01; Chief Bur. Soils, U. S. Dept. Agr., '94—.

1898. John Charles Whitten, B. S. (S. Dak. Agr. Coll., '91), M. S. (do., '99), Ph. D. (Univ. Halle, '02); *Columbia, Mo.;* Instr. in Hort. and Hort. Expt. Sta., S. Dak. Agr. Coll., '92; Asst. in Hort., Mo. Bot. Gard., '93–'94; Prof. Hort. and Hort. Expt. Sta., Univ. Mo., '94—.

1911. John Andreas Widtsoe, B. S. (Harvard Univ., '94), Ph. D. (Univ. Göttingen, '99); *Logan, Utah;* Chem., Utah Expt. Sta., '94–'05; Prof. Chem., Utah Agr. Coll., '95–'05; Dir. Utah Expt. Sta., '00–'05; Dir. School of Agr., Brigham Young Univ., '05–'07; Pres., Utah Agr. Coll., '07—.

1908. Harvey Washington Wiley, A. B. (Hanover, '67), M. D. (Indiana Med. Coll., '71), B. S. (Harvard, '73), Ph. D. (Hanover, '76), LL. D. (do., '98); *Washington, D. C.;* Prof. Chem., Butler, '73–'74; Prof. Chem., Purdue Univ., '74–'83; State Chem., Ind., '81–'83; Chief, Div. Chem., U. S. Dept. Agr., '83–'01; Chief, Bur. Chem., do., '01–'12; Writer and Lecturer, '12—.

1912. JULIUS TERRASS WILLARD, B. S. (Kans. Agr. Coll., '83), M. S. (do., '86), D. Sc. (do., '08); *Manhattan, Kans.;* Asst. in Chem., Kans. Agr. Coll., '83–'87; Asst. Prof. Chem., do., '90–'96; Assoc. Prof. Chem., do., '96–'97; Prof. Appl. Chem., do., '97–'01; Prof. Chem., do., '01—; Dean, Div. Gen. Sci., do., '09—; Asst. Chem., Kans. Expt. Sta., '88–'97; Chem., do., '97—; Dir. do., '00–'06; Chem., Kans. Engin. Expt. Sta., '10—.

1912. CHARLES BURGESS WILLIAMS, B. S. (N. C. Agr. Coll., '93), M. S. (do.,' 96); *West Raleigh, N. C.;* Asst. Chem., N. C. Dept. Agr., '93–'06; Agron., do., '06–'07; Dir. and Agron., N. C. Expt. Sta., '07–'12; Vice Dir. and Agron., do., '13—.

1908. CARLOS GRANT WILLIAMS, *Wooster, Ohio;* Agron., Ohio Expt. Sta., '03—.

1911. WILLIAM ALPHONSO WITHERS, A. B. (Davidson Coll., '83), A. M. (do., '85); *West Raleigh, N. C.;* Asst. Chem., N. C. Expt. Sta., '84–'88; Prof. Chem., N. C. Agr. Col.., '89— ;Statis. Agt., U.S. Dept. Agr., '95–'02; Acting Dir., N. C. Expt. Sta., '97–'99; Chem., do., '97—.

1909. FRITZ WILHELM WOLL, B.S. (Royal Frederiks Univ., Christiania, '82), Ph. B. (do., '83), M. S. (Univ. Wis., '86), Ph. D. (do., '04); *Madison, Wis.;* Asst. Chem., Wis. Expt. Sta., '87–'97; Chem., do., '97—; Asst. Prof. Agr. Chem., Univ. Wis., '93–'04; Assoc. Prof., do., '04–'06; Prof., do., '06—.

1903. ALBERT FREDERICK WOODS, B. Sc. (Univ. Nebr., '90), A. M. (do., '92); *University Farm, St. Paul, Minn.;* Asst. Bot., Univ. Nebr., '91–'94; Asst. Chief Div. Veg. Path., U. S. Dept. Agr., '94–'00; Chief, do., '01–'09; Asst. Chief, Bur. Plant Indus., do., '01–'09; Dean Coll. of Agr., Univ. Minn., and Dir. Expt. Sta., '10—.

1903. CHARLES DAYTON WOODS, B. S. (Wesleyan Univ., Conn., '80), D. Sc. (honorary, Univ. Me., '05); *Orono, Me.;* Asst., Chem., Wesleyan Univ., '80–'85; Instr. Sci., Wilbraham Acad., Mass., '83–'88; Chem., Conn. Storrs Expt. Sta., '88–'96; Vice Dir., do., '89–'96; Prof. Agr., Univ. Me., '86–'03; Dir. Maine Expt. Sta., '96—.

1911. BONNEY YOUNGBLOOD, B. S. (Tex. Agr. Coll., '02), M. S. (do., '07); *College Station, Tex.;* Prin. and Instr. in Agr., Henderson, Tex., City Schools, '03–'05; Prin. and Instr. in Agr., Mineola, Tex., High School, '05–'06; Supt. City Schools and Instr. in Agr., Pauls Valley, Okla., '06–'07; Asst. Agr., Office of Farm Management, U. S. Dept. Agr., '07–'11; Dir., Tex. Expt. Sta., '11—.

1910. C. A. ZAVITZ, B. Sc. (Toronto Univ., '88); *Guelph, Canada;* Asst. Expt. Dept., Ontario Agr. Coll., '86–'93; Head of Expt. Dept., '93—; Prof. of Field Husbandry, Ontario Agr. Coll., '04—.

Deceased Members.

Robert Fairchild Kedzie,	Born Dec. 9, 1852	Died Feb. 13, 1882
Lauren Briggs Arnold,	" Aug. 13, 1814	" Mar. 7, 1888
George Hammel Cook,	" Jan. 5, 1818	" Sept. 22, 1889
Patrick Barry,	" May 24, 1816	" June 24, 1890
John J. Thomas,	" Jan. 8, 1818	" Feb. 22, 1895
Charles Valentine Riley,	" Sept. 18, 1843	" Sept. 14, 1895
Charles Lee Ingersoll,	" Nov. 1, 1844	" Dec. 15, 1895
Edward Louis Sturtevant,	" Jan. 23, 1842	" July 30, 1898
Sir John B. Lawes, *Hon. Mem.*,	" Dec. 28, 1814	" Aug. 31, 1900
John Alvah Myers,	" May 29, 1853	" April 8, 1901
Sir Henry Gilbert, *Hon. Mem.*,	" Aug. 1, 1817	" Dec. 23, 1901
Robert Clark Kedzie,	" Jan. 28, 1883	" Nov. 27, 1902
Victor Hunt Lowe,	" Sept. 23, 1869	" Aug. 27, 1903
Henry English Alvord,	" Mar. 11, 1844	" Oct. 1, 1905
Robert Warington, *Hon. Mem.*,	" Aug. 22, 1838	" Mar. 20, 1907
Willis Grant Johnson,	" July 4, 1866	" Mar. 11, 1908
James Fletcher,	" Mar. 28, 1852	" Nov. 8, 1908
Samuel William Johnson,	" July 3, 1830	" July 21, 1909
William Henry Brewer,	" Sept. 14, 1828	" Nov. 2, 1910
Charles Anthony Goessmann,	" June 13, 1827	" Sept. 1, 1910
Samuel B. Green,	" Sept. 15, 1859	" July 11, 1910
Welton M. Munson,	" April 8, 1866	" Sept. 9, 1910
Edward Burnett Voorhees,	" June 22, 1856	" June 6, 1911
Franklin Hiram King,	" June 8, 1848	" Aug. 4, 1911
Oskar Kellner, *Hon. Mem.*,	" May 13, 1851	" Sept. 22, 1911
John Bernhardt Smith,	" Nov. 21, 1858	" Mar. 12, 1912
Melville Amasa Scovell,	" Feb. 26, 1855	" Aug. 15, 1912

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SOCIETY FOR THE

PROMOTION OF AGRICULTURAL SCIENCE

PROCEEDINGS

OF THE

THIRTY-FOURTH ANNUAL MEETING

WASHINGTON, D. C., NOVEMBER 11, 1913

PUBLISHED BY THE SOCIETY

1914

Proceedings

of the

Thirty-fourth Annual Meeting

of the

Society for the Promotion

of

Agricultural Science

HELD AT

WASHINGTON, D. C.

NOVEMBER 11, 1913

Edited by the Secretary

E. W. ALLEN

PUBLISHED BY THE SOCIETY

1914

CONTENTS.

The Washington Meeting, 1913

By E. W. Allen,

Secretary-Treasurer

The thirty-fourth annual meeting of the Society was held at Washington, D. C., November 11, 1913, in connection with the annual convention of the Association of American Agricultural Colleges and Experiment Stations, and the meetings of several other agricultural organizations. Morning, afternoon and evening sessions were held, in the New Willard Hotel.

Arrangements were again made for joint sessions with the American Society of Agronomy in the afternoon and evening. The afternoon program was made up with reference to the presentation of matters of quite general interest. At the joint evening session the two presidential addresses were delivered, Dr. B. T. Galloway, Assistant Secretary of Agriculture, presiding. The address of Dean E. Davenport, of this Society, was on the subject, How Will Extension Work React Upon Research? (see page ——), and that of Prof. L. A. Clinton, of the American Society of Agronomy, treated in a suggestive manner The Agronomist in His Relation to the Farmer.

These joint sessions with the American Society of Agronomy constitute the only tangible product of the effort for the affiliation or closer cooperation of agricultural societies. The results as far as the two societies go are found most satisfactory, and if other societies could be prevailed upon to hold their meetings at the same time these benefits might be extended. The present tendency to make the annual convention of the Association of American Agricultural Colleges and Experiment Stations a center for the meetings of other societies suggests the feasibility of such an extension.

In addition to the presidential addresses, nine papers were presented at the morning and afternoon sessions, these with the discussions making quite a full program for the two sessions. All of these papers are printed in the following pages except that of Prof. W. J. Spillman, on Factors of

Efficiency in Farming. This paper will appear as an article in the Yearbook of the Department of Agriculture for 1913, and hence was not available for the Proceedings.

BUSINESS MEETING.

The Secretary reported that the Society had more than held its own during the year. There were no deaths or withdrawals. The ten new members elected at the Atlanta meeting brought the active membership up to 144, a gain of nine members.

At the business meeting the names of twelve candidates were presented for membership and elected, all but two of whom have qualified as members. The list of new members is as follows: Prof. H. O. Allison, Animal Husbandman, University of Missouri and Experiment Station; Mr. J. W. Ames, Chemist, Ohio Experiment Station; Prof. M. A. Blake, Horticulturist, Rutgers College and New Jersey Experiment Stations; Prof. R. J. H. DeLoach, Director, Georgia Experiment Station; Prof. C. H. Eckles, Dairy Husbandman, University of Missouri and Experiment Station; Mr. J. A. Fries, Assistant Director, Institute of Animal Nutrition, Pennsylvania State College; Prof. Martin Nelson, Director, Arkansas Experiment Station; Mr. J. B. Rather, Assistant Chemist, Texas Experiment Station, and Dr. G. M. Reed, Botanist, and Dr. P. F. Trowbridge, Agricultural Chemist, University of Missouri and Experiment Station. This brings the list of regular members up to 154, with one honorary member.

The Secretary reported that he had again represented the Society on the supervisory board of the American Year Book, and with the assistance of a number of specialists had contributed the review of agriculture for the 1913 Year Book, the articles aggregating about twenty-eight printed pages. In this undertaking the Society has joined hands with many leading scientific, economic, historical and other societies, in an effort which is giving a creditable year book of American affairs.

The treasurer's report, submitted by E. W. Allen, was as follows:

Report of Treasurer, 1912–1913.

Cash on hand November 9, 1912	$304.18	....
Receipts from annual membership dues	260.20	....
Receipts for extra separates	4.50	....
Received from Assistant Custodian, November 7, 1913, on account of sales of Proceedings	40.00	....
Interest on bank deposit ($2.71+$3.24)	5.95	....
Printing Proceedings of thirty-third meeting	....	$302.11
Illustrations for same	....	18.00
Premium on insurance of Proceedings in hands of Assistant Custodian	....	24.00
Expenses of Custodian, Dr. W. J. Beal	....	6.63
Printing letter heads, announcements, and programs	....	7.60
Painting signs for Atlanta meeting	....	1.00
Postage and telegram	....	16.17
Stationery, envelopes, etc	....	2.50
Balance in bank November 10, 1913	....	196.82
Uncashed check from Prof. W. D. Hurd	....	40.00
Total	$614.83	$614.83

This account was audited by Dr. C. D. Woods and Prof. W. D. Hurd, and found correct.

The statement of the Assistant Custodian, Prof. W. D. Hurd, was as follows:

Report of Assistant Custodian from November 1, 1912, *to November* 1, 1913

Sale of Proceedings:

State College of Washington	$0.55
Clark University	.54
N. C. Experiment Station	.54
Minneapolis Public Library	.54
Cleveland Public Library	.54
New Hampshire State College	1.08
Yale University	.54
New York Public Library	.54
Oregon Agricultural College	.50
Ontairo Agricultural College	.54
Carnegie Library, Pittsburgh	.54
State College of Washington	.54
University of Maine	.50
Ohio Agricultural Experiment Station	.54
Montana Agricultural College	16.00
St. Louis Public Library	16.00
John Crerar Library, Chicago	1.62
University of California	.55
South Dakota State College	.50

Geo. E. Stechert Co.	1.08		
University of Wisconsin	.54		
		$44.32	
Envelopes sold		.34	
Balance on hand November 1, 1912		19.98	
Postage for stamp drawer			$1.00
Bill heads			1.75
Postage on shipments			.37
200 envelopes for ballots			4.32
Printing of ballots			5.25
Printing of postal cards for final ballots			5.00
Student's time in taking inventory			.45
Check to Dr. Allen, treasurer			40.00
Balance on hand			6.50
		$64.64	$64.64

On the outstanding accounts bills receivable amounting to $27.24 were reported.

A careful recount of the volumes of the Proceedings on hand showed a difference of 506 from that of last year. This year's count showed that there must have been on hand in November, 1912, 5,771 volumes, instead of 5,265, as reported. The last inventory shows the following:

Volumes on hand November 1, 1912	5,771
Volumes received during year (Vol. 33)	236
	6,007
Volumes sold during year	88
Volumes on hand November 1, 1913	5,919

Invitations were presented by the Secretary for the Society to hold its 1914 meeting in New York City, and in 1915 at San Francisco, in connection with the Panama-Pacific Exposition. No action was taken on the invitations, the place of the next meeting being left to the executive committee.

The following officers were elected for the ensuing year: President, President H. J. Waters, Manhattan, Kans.; Secretary-treasurer, E. W. Allen, Washington, D. C.; member of the executive committee for three years, Dr. H. P. Armsby, State College, Pa.

The Society voted to refer to the executive committee, with power, the proposal to amend the rule regarding the method of election of officers.

How Will Extension Work React Upon Research?

PRESIDENT'S ADDRESS.

By E. Davenport,

Illinois College of Agriculture and Experiment Station.

Of the three great agents of agricultural advancement, teaching, research, and demonstration, each has had its period of prominence. All are good, all are necessary, but it is important that a true balance be preserved.

Roughly speaking, ten years ago it was instruction to the young that lay heaviest and most constantly upon men's minds. Five years later it was experimentation, and money and interest were freely devoted to the learning of new truth. Now, without a doubt, demonstration is the popular thing with the public and with many college people themselves; for that which is most easily advocated is quite naturally most popular.

It is easy to say that we are piling up information in cold storage, and instead of putting more unused knowledge into pickle it is better to devote money and men to the business of getting the knowledge that we do possess out among the people, putting it at work where it will do some good. It is easy to say all this, without stopping to consider whether any of it is true. In fact, it is not true. We do not yet possess a very large stock of really well-established new knowledge. It is not in cold storage, for it is all in print, not only in official reports but in the newspapers, and it is taught in hundreds of colleges and schools.

It is not true that the people do not read the bulletins: they do read them, and they do read the papers, and they do profit by them both. The only thing that demonstration and individual advice can do is to hasten improvement a little by enlarging the number that can be reachd; though a good per cent of farmers will never be reached by any effective agent but the undertaker—who, after all, is a great civilizer. I do not say this in reproach, only by way of noting that a considerable percentage of men pride them-

selves in being "queer"—which is a bit of psychology that the demonstrators do well to heed.

But such extravagant claims have been made for all forms of extension work, especially farm demonstration, and so industriously have the terms "cold storage" and "shooting over the heads of farmers" been used that the really effective and only ultimate agents of progress, the colleges and the research laboratories, are in danger of being overshadowed by the very extension work to which they have given birth. Like many useful organisms they may languish in their own product, paralyzed by the results of their own activities.

From any such toxic consequences may we be delivered; and yet thinking men today see a real peril both to the college and to the station in the excessive claims and praises of extension work, much of which must in the nature of the case pass away with the present generation of relatively unschooled farmers.

It is worth our while to analyze conditions the best we can and endeavor to learn the nature and extent of this peril, together with any mitigating influences that may be at work,—the latter being especially welcome seeing that the college and the station have been mutually strengthening and not destructive.

WHERE EXTENSION WORK IS DOING DAMAGE.

The insistent if not excessive campaign for larger and still larger funds for extension service, instead of strengthening the colleges and stations financially as has been assumed, will be found under present conditions to operate adversely to divert funds and interest from both the college and the station at the very time when they are most needed; when students are overrunning our colleges, and when the stations ought to be richly endowed in order to prosecute researches necessary to answer the questions that these same students of ours will be asking within a score of years or less. They will know how to ask questions, and they will also know the difference between words and facts.

Then and not now is when the stations and the men re-

sponsible for present-day policies will be tested in the crucible. I wonder if we realize it, or are we being carried on a wave of popularity—the first real response to the service of science in aiding agriculture?

We are so abundantly satisfied with so few and such small facts, and we are making such a great to-do about their demonstration, that we resemble nothing so much as a fussy old hen nursing one chicken, while the unhatched eggs cool off and die.

This is no joke. Here is a real peril to the solid business of teaching and research, especially the latter. Its reality can be brought out by a few questions:

(1) In our various States is it not true that ten men are employed in circulating agricultural information for every one who is seriously engaged in research likely to result in notable addition to the sum total of agricultural knowledge?

(2) How does the public interest today compare with that of half a decade ago? Are not most of the men, and is not most of the talk concerned with demonstration or other forms of extensive work intended to reach the mature farmer upon his farm?

(3) Of the 14,000 men and $20,000,000 of money of the Department of Agriculture, how many and how much go to the solid business of adding to the sum of human knowledge?

(4) Of all the projects now before us for raising money, state or federal, how pitifully small are those designed to promote in a large way, either teaching or research, as compared to the enormous sums and the gigantic organizations proposed for the conduct of extension work.

So much for mere mass effects showing that we may well feel solicitous for both the college and the station, especially for the latter, which cannot hope to compete either in spectacular show or in immediate promise with its younger but robustious brother, the extension service.

The more immediate promise of extension work appeals mightily to the imagination of young men. It challenges and interests their energy and their vision for doing good, and sometimes their itching for popularity. Experimentation and even teaching seem prosy if not inconsequential

beside it, and more than one good man and more than one good department has been ruined for serious work by the intoxication of demonstration promising immediate and tangible results.

It is all very demoralizing to many of our young men, and it comes at a time when young men are sorely needed to keep up the supply and restock the institutions with a generation of scientists better prepared than are we who are in the service now.

Instead of stimulating young men to profound scholarship in preparation for the highest grade of scientific service by and by, most of the influence is the other way, for a bright young man with a B. S. degree can earn more money and seem to be doing more good in extension work than he could by devoting his time and his means for ten years in improved preparation. All this is bound to tell on the future supply of qualified men. It is true that not all are caught by the glitter, but a large number of excellent men are diverted just now when we need them most, not so much in service as in further academic preparation for service.

Demonstration is often a mask for poor work, and extension service in general is demoralizing except to matured men of the highest training. The temptation to short circuit an embarrassing situation when sudden questions arise with no opportunity of consulting authorities is akin to that which animates the quack to give a ready if not a correct diagnosis and remedy. In a very large and immediate sense, extension work tends to lower standards and discourage high and exact scholarship.

ADVANTAGES.

On the other hand, the better form of extension work in the shaps of farm demonstration, when in the charge of the best men, is a powerful adjunct of the experiment station in two respects:

(1) The farm demonstrator who is really capable constitutes the best possible means of reaching the farmers with the results of research and the new practices that are indicated.

(2) The demonstrator, not the talker, will be and is in a position to discover slight shades of deviation in established principles as they are applied to local situations, and is thus a constant source of new points of view and new experiments or modification of standard information. He is, next to the graduate on his own farm, the best yardstick with which to measure new ideals and new attempts at improved practice.

By all standards of judgment the capable demonstrator actually living in the field is an agent of progress, but the illy prepared extension worker is a menace to the progress of science in its service to agriculture.

WHAT IT ALL MEANS.

It all means that great confusion exists in the public mind as to the relative importance of science and its applications. We will all agree, I am sure, that science is useful and worth while only when applied to actual affairs; but we will also agree, I am sure, that our stock of knowledge is not yet sufficiently large to warrant the public in devoting its main energies to its dissemination.

If, however, this is not to be done at this juncture, those who are in a position to influence public thought and legislation must be exceedingly wise as to the proper balance to be maintained between extension service and real research, which alone represents actual contribution to human knowledge. There is much danger now of confusion as between the two, and this is the time for real scientists to distinguish clearly between the shadow and the substance, lest the colleges and the stations suffer just as they are about to enter upon what ought to be the period of their greatest usefulness.

The really significant element in an improved agriculture is not the father but the son, and this improvement that is to come, so far as it is substantial and abiding, is to come mainly through college graduates and undergraduates who return to the farm. The regeneration of American agriculture will be a process working from within and not a thing laid on like a garment from without.

Already these young men are asking questions we cannot answer. Ten years later they will ask more questions and they will be harder to answer. Are not men and money both being diverted that ought to go freely into research of the profoundest character? Sometime that question will be asked in a way to demand an answer.

Now these are questions to be considered by those who are most responsible for what is now being done. It is upon them, whatever else is done, to insist upon and to maintain at all cost a proper balance between real research and all other agencies for agricultural progress, however attractive, however expedient, however necessary.

Feeding Experiments to Determine the Availability of Protein.[1]

By Burt L. Hartwell and Robert A. Lichtenthaeler,

Rhode Island Experiment Station.

It is with some hesitation that we venture to present a few thoughts which have arisen at the Rhode Island Station in the course of a series of feeding experiments, carried on usually for fifteen weeks with chickens about four weeks of age at the beginning of the experiments. The main object was to determine the relative feeding value of the protein in certain concentrates.

It is not proposed to dwell on the details of the experiments, for these may be found in Bulletin 156, now being compiled; but to ask for your consideration of the method of experimentation with the hope of receiving profit from any possible discussion which may follow.

In far too many instances, feeding tests with young animals or with milch cows are carried on with different protein concentrates under conditions so indefinite as to render impossible even approximate deductions as to whether the concentrate was acting as a source of nitrogen, of energy, or of both; or, indeed, whether an opportunity existed for the full effect to be exerted in any capacity.

This situation exists when no effort is made to prove the elimination of those factors which are assumed to be exerting an unimportant influence, or to establish without doubt that the supposed active factor was exerting only a sub-optimal influence, a very necessary consideration if it is to be given an opportunity to exert its full action. The frequent apparent lack of consideration of what appear to be essential features of a feeding experiment by which it is presumed to determine the nutrient effect of some ingredient of animal or plant food, affords an excuse for dwelling for a few minutes on certain points, even at the risk of presenting some perfectly obvious ideas.

With plants, so many experiments have been carried on to

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[1]Contribution 202 from the Agricultural Experiment Station of the Rhode Island State College.

determine the availability of phosphorus, potassium or nitrogen that one would expect full attention to be given to the essentials; and yet in how many cases, in determining the availability of nitrogen for example, does the experimenter fail to prove, by the introduction of plats or pots receiving additional phosphorus and potassium, whether these were present in optimal amounts? And, again, how often he fails to apply an amount of nitrogen in excess of that which is used as a standard of comparison, in order to make sure that the latter is not in excess of the optimal requirements for growth? Failure to insist upon the introduction of these additional plats or pots has led to much conflicting data.

In the more recent of the experiments with chickens previously referred to, attention was fixed chiefly upon determining the value of beef scrap and cotton-seed meal as sources of protein. Each lot of chicks ate the same amount of a basal ration composed of mash and scratch feed. The mash included bone ash and a variety of feeds so that there probably would be no omission of any possible unrecognized essential compound; even a small quantity of the concentrates being tested was added to the basal mash. It was desired that it contain only a small amount of protein, but the presence of a variety of feeds, including wheat bran and clover or alfalfa for the purpose of maintaining a desirable physical condition of the mash, even allowing for the addition of certain supplemental feeds, resulted in an approximate nutritive ratio of 1:5.* The basal scratch feed, however, was composed of cracked corn and rice, and had a ratio of 1:9.5. When the two were fed in equal amounts, a ratio of 1:7 existed in the entire basal ration. As might be expected, the chicks made but a very slow growth on this ration, even when they were given all they would eat, and frequently grew comparatively few feathers.

In order to see whether such chicks could make any further use of non-nitrogenous food, another lot was given an addition of starch, sugar and cotton-seed oil, resulting in a nutritive ratio of 1:8.5. Although these chicks were some-

*Fiber and digestibility coefficients are not taken into consideration.

what fatter at the end of the experiment, they contained no more dry matter and nitrogen.

Still other lots of chicks received in addition to the common basal ration, equal amounts of nitrogen in beef scrap or in cotton-seed meal. In order to emphasize any difference in effect which might be caused by the two concentrates, nearly as much protein was fed in them as in the entire basal ration. This resulted in a nutritive ratio of about 1:4.

It remained next to be proven whether the protein concentrates were fed in sub-optimal amounts so that a more rapid growth could be produced by the addition of still more protein. This was done by including another lot of chicks which received still more beef scrap, the nutritive ratio becoming about 1:3. These made a larger growth, but one could not be certain whether it was attributable to the protein or to the other constituents of the beef scrap.

It was necessary, therefore, to throw light upon the effect, by themselves, of non-nitrogenous constituents equivalent to those in the extra amount of beef scrap just referred to. This was done by adding starch, sugar and mutton fat to those rations containing the sub-optimal amount of protein concentrates. Again, the chief effect of such an addition was the production of fatter chicks. There was in this instance, however, a small apparent increase in the dry matter and nitrogen in the chickens as prepared for cooking. There remained no doubt, however, that the increase in growth due to the largest amount of beef scrap was at least mainly attributable to the nitrogen, and that the rations containing the medium amounts of the two protein concentrates were really sub-optimal so far as concerned maximum growth and nitrogen-recovery.

The question of whether the medium rations of the protein concentrates, to which reference has just been made, produced their effect mainly as sources of protein is more difficult to answer. The fact that the addition of the non-nitrogenous feeds to only the basal ration had no effect on the weight of the small chicks produced in that case, cannot be taken as proof that the larger chicks resulting from the addition of the medium amount of protein concentrates,

would not have required enough more energy food so that the non-nitrogenous constituents of the concentrates may have had some influence on the amount of growth.

The furnishing of indications on this point would require the introduction of pens of chicks to receive the medium ration modified by a reduction in the amount of non-nitrogenous constituents equivalent to those supplied in the two protein concentrates. If this reduction in food resulted in no loss in weight, it might then be claimed that the protein of the concentrates was the only ingredient influencing growth. A measure of the influence of the protein from the two sources would then have been obtained.

In case of a basal ration such as was adopted in the experiments under discussion something approaching the foregoing might have been accomplished, in part at least, by removing some of the less-nitrogenous feeds and replacing the protein in them by the same amount from highly nitrogenous ones. This would have constituted an exception, however, to the uniformity of the accepted basal ration. Although a fairly satisfactory modification might have been made which would have resulted in the net removal of ingredients isodynamic with those *other* than the protein, the difficulty would have been increased if, in addition, an attempt were made to remove an amount isodynamic also with the protein. This latter procedure would, of course, be necessary if an attempt were made to attribute the effect of the proteins to their food value as sources only of nitrogen instead of also as sources of energy. An addition, for example, of 100 parts of beef scrap containing 55 per cent of protein and 15 per cent of fat would necessitate the removal from the basal ration of the equivalent of about 90 parts of starch. Considering that nearly half of the entire amount of protein in the medium rations was in the concentrate, this would have led to a more serious modification in the basal ration than it was desired to make.

The removal of such a large amount of energy without also removing nitrogen could perhaps be most easily accomplished by including in the general basal mash liberal amounts of such material as starch, sugar and fat, so that in the special cases being considered, it would be necessary

only to remove all or a portion of these ingredients. One sees difficulty in securing in such a basal ration a desirable physical condition and at the same time a sufficient preponderance of nitrogen-free ingredients so that there would be no growth effect attributable to the added concentrates acting as sources of energy instead of as sources of nitrogen.

The comparison discussed above was not attempted in the present experiments, but the main reliance concerning the availability of the nitrogen for meat production was placed on the determination of that recovered in the chicks after cooking them in a steam-box. They were prepared for cooking in the usual manner, and all the edible giblets were included. The dry matter, nitrogen, ether-extract and crude ash were determined in the bones, which were carefully separated by hand, and also in the remainder of the chicks, including the skin and soup.

Only brief mention can be made at this time of the results of the experiments. To enable a ready comparison of the average weights in case of lots receiving the medium or sub-optimal amount of protein, those for the cotton-seed meal lots are here recorded in their relation to 100 as representing the weights of the beef-scrap lots.

RELATIVE WEIGHTS OF COTTON-SEED MEAL LOTS
(BEEF-SCRAP LOTS AT 100)

Experiment.	*Alive.*	*Dressed.*	*Prepared for cooking.*	*Cooked, water-free.*
I	94	91	...	...
IV	91	99	89	86
V	117	116	109	107
VI	92	...	...	...
VII	90	...	...	...
VIII* 8*a*	102	105	104	98
VIII* 8*b*	107	108	105	105
Average of above	99	104	102	99

**a* refers to lots which received no extra non-nitrogenous feed, and *b* to those which did.

One would hesitate to conclude from these results that the protein in one of the concentrates was superior to that in the other. It should be remembered that the feed was so given that all lots in an experiment ate the same amount of the basal ration. The supplements to this ration constituted that much additional food. The amount of feed was limited by the lot of chicks which ate its food least readily, and they were allowed to eat *ad libitum.*

If it be conceded that the amount of nitrogen recovered in the cooked chicks which received the basal ration alone was equal to that recovered from the same foods when in association with the medium amounts of protein concentrates, the difference between the amount of nitrogen in the smaller and larger chicks, respectively, produced without and with the additional protein concentrates, may be attributed to the concentrates.

The data are arranged from this standpoint in the accompanying table, in which the nitrogen recovered from the protein concentrates themselves is considered to be the difference between the nitrogen in the chicks which received only the basal ration and in those receiving also beef scrap or cotton-seed meal.

NITROGEN RECOVERED FROM THE PROTEIN CONCENTRATES FED TO CHICKENS.

Experiment.	*Grams of nitrogen in the average cooked chicken.*			*Grams of nitrogen recovered from the concentrate.*		*Grams of nitrogen added in the concentrates.*
	Beef-scrap lots.	*Cotton-seed meal lots.*	*Basal ration lots.*	*Beef scrap*	*Cotton-seed meal*	
IV	17.20	13.73	7.95	9.25	5.78	38.1
V	13.68	15.57	7.40	6.28	8.17	35.8
VIII, a	15.05	15.25	8.50	6.55	6.75	35.7
VIII, b	15.51	15.73	8.50	7.01	7.23	35.7
	61.44	60.28	32.35	29.19	27.93	145.3

Considering the variation in the different experiments one would again hesitate, before concluding that the availability of the nitrogen in the two concentrates had been proven to be different.

It may be said in passing that no certain evidence of a toxicity of cotton-seed meal was secured, although many observations were made concerning this point. This was true even when in certain instances the experiments were continued until the chicks reached maturity. When fed *ad libitum*, however, the chicks consumed more of the mash when it contained the medium amount of beef scrap than when the latter was substituted by cotton-seed meal, and made a correspondingly larger growth.

For present purposes it seems best to limit the discussion by considering only the average results with the two protein concentrates. In co-relation with the content of protein, the rations containing only the protein of the basal mash will be referred to as "low," those containing the sub-optimal amount as "medium," and those containing the largest amount of beef scrap as "high."

At the age of about nineteen weeks the average weight in pounds was as follows: live weight, low ration .95, medium ration 1.63, high ration 1.91; weight as prepared for cooking, low ration .60, medium ration 1.08, high ration 1.23. The grams of nitrogen found in an average cooked chicken were as follows: low ration 7.96, medium ration 15.22, high ration 17.72, and in the edible portion of a cooked chicken fed on a low ration 6.58, medium ration 12.97, high ration 14.64.

In accordance with the foregoing data it appears that the percentage increase caused by the addition of the medium amount of protein concentrate was as follows: live weight 72, weight prepared for cooking 80, total nitrogen in the cooked chick 91, and in the cooked edible portion 97.

It is shown by these percentages that had the efficiency of the protein concentrates been measured simply by the percentage increase in weight of chicks, a lower value would have been obtained than was secured by an analysis of the chicks.

The average amount of nitrogen in a chick prepared for

cooking was about 1.58 grams at the beginning of an experiment, according to the analysis of four individuals in one case. If this amount is subtracted from the nitrogen in an average chick at the end of an experiment, the difference may be considered as having been recovered from the nitrogen consumed in the feeds. On this basis the percentage recovery of the nitrogen consumed was as follows: in an entire chick as prepared for cooking, low ration 15.2, medium ration 17.6, high ration 16.3. These figures are given to show that in the medium ration, which was designed to give opportunity for the protein concentrates to exert their full efficiency, there was probably a better actual recovery than in the case of either the low or high rations.

In case of the medium ration, 17.6 per cent of the nitrogen added in beef scrap or cotton-seed meal was actually recovered in the edible part of a chick.

The Nutritive Values of Organic and Inorganic Phosphorus

By E. B. Forbes,

Ohio Experiment Station.

Considering the phosphorus of the animal body as a whole, the most obvious distinction among the various groups of its compounds is that certain of these are organically combined, as a part of the living tissue, being fundamentally involved in all vital activities, while others are simple salts of the mineral bases, either deposited in supporting structures, or dissolved in the body fluids.

In both cases the phosphorus itself, so far as known, is present in the same completely oxidized form, as simple phosphoric acid, differing only in its chemical relationships. These facts are true, not only of animal bodies, but also of foodstuffs. This paper is a consideration of the evidence as to the *nutritive limitations* imposed by these differences in relationship of phosphoric acid in foods. We wish to know whether organic and inorganic phosphorus compounds can serve equally well, all of the requirements of the body for phosphorus under all conditions of life, and shall restrict this consideration to this one point of relative nutritive value.

Let us consider first the eggs of birds, for the egg assuredly contains all of the nutrients required by the fully-formed animal. Examining the phosphorus of eggs we find a wealth of organic compounds, but, at the most, mere traces of inorganic phosphates. It is thus obvious that organic phosphorus compounds can serve all of the needs of the body for this element. But our interest is in foodstuffs; an egg is a foodstuff in the usual sense only for the one who steals it. Let us consider the first natural food of young mammals, the mother's milk. Are the relative amounts of organic and inorganic phosphorus related to the food requirements of the young animal, or do they simply represent their relative availability for milk production in the maternal organism?

However this may be, if there is not an adaptation of the character of the food to the requirements of the young, then we would look for an adaptation of the method of development of the young to the possibilities of the food; in either case a harmony of objects to be attained and means for their attainment.

In this light we would naturally assume that both organic and inorganic phosphorus compounds are of benefit to the animal, for both classes are represented in milk by several individuals each; and in the whole literature of the subject there is scarcely a dissenting voice raised against this idea. Both organic and inorganic phosphorus are absorbed and retained.

But now we come to the parting of the ways. If organic phosphorus can serve all of the requirements of the body for phosphorus, and if inorganic phosphorus can be absorbed and retained, are organic and inorganic phosphorus equally useful for all of the purposes for which the body needs phosphorus. Our economic reason for desiring an answer to this question lies in the relative accessibility of organic and inorganic phosphorus for use as food. If rock phosphate and old bones can furnish us phosphorus in the forms most advantageous for the growth of animals, we are wasting a lot of money on milk, eggs and beef, for there are much cheaper sources than these, or protein, fat and carbohydrates.

It would seem that so simple a problem ought readily to be solved, but when we approach the subject by direct experiment we find the course beset with hazards, and there has never been unanimity of opinion as to the facts. Among those circumstances which have contributed to this difference of opinion are:

1. An inclination to ascribe to all animals under all conditions of life all capacities of synthesis possessed by any animal under any condition, natural or experimental, no matter how great the stress of attending circumstance.

2. Drawing conclusions from very short balance experiments, without due regard to states and habits of nutrition as determined by previous feeding.

3. A failure to distinguish between bare physiological

minima and maximum practical optima. The whole range of success and profit in animal production lies close to the latter.

4. Drawing conclusions from mere gain in weight, without actual estimation of the compounds of interest, in the experimental animals and in carefully selected controls, the error in so doing being that it implies the maintenance of constancy of composition and function, the variability of which, as affected by feeding, usually being denied and still more commonly under-estimated.

5. Drawing conclusions from analyses of parts of animals, a complete chemical accounting being desirable.

6. Failure fairly to meet the great difficulties of compounding rations which do not differ in essential ways other than the point of interest, that is, in the *condition* in which the phosphorus is present.

7. It is quite possible that useful enzymes associated with the organic phosphorus compounds have contributed to their supposedly superior nutritive value.

8. Unsatisfactory mineral salt mixtures may have limited usefulness of other nutrients in such a way as to result in unfair comparisons.

I shall mention very briefly a few of the investigations on this subject.

Hall (1896), from feeding experiments with mice, came to the conclusion that the salts organically combined with casein have a greater nutritive value than salts not so combined.

A considerable number of balance experiments with dogs have also been conducted in the comparison of the phosphorized proteins, casein, and vitellin with the phosphorus-free myosin and edestin plus inorganic phosphates. Some such experiments are those of Steinitz (1898), Röhmann (1898), Leipziger (1899), Ehrlich (1900), Gottstein (1901) and Hirschler and Terray (1902) and (1905). In every one of these earlier investigations the retention of phosphorus was greater from the phosphorized proteins than from the phosphorus-free proteins, and the inorganic phosphates. One blanket criticism will fairly cover this whole series of investigations. They were of short duration, and

previous adaptation to the use of phosphorized proteins may have been prejudicial to the use of the phosphorus-free proteins and phosphates; still, harmonious results from so many workers must be considered to represent the facts under the conditions of these experiments.

Another experiment of like import was that of Kornauth (1900) who found 2-3 times as much phosphorus in the form of egg albumin and serum albumin precipitated by metaphosphoric acid, necessary to maintain phosphorus equilibrium, as of natural animal and vegetable phosphorus compounds.

Balance experiments with infants by Cronheim and Müller (1900) and Zuntz (1900) showed the superior value of the organic phosphorus of egg yolk as compared with the phosphorus compounds of milk.

Gilbert and Posternak (1905), using phytin, Tunnicliffe (1906) using sanatogen, and Egbert Koch (1906) from experiments with milk, reported balance data from human beings in the comparison of organic and inorganic phosphorus compounds. It is easy to point out faults in their experimental conditions. As in the earlier work, so in these three investigations, the comparison was in every case in favor of the organic phosphorus compounds.

Hart, McCollum and Fuller (1909) compared organic and inorganic phosphorus compounds with swine. These experiments show that swine can live on rations which are very low in organic phosphorus if plenty of inorganic phosphorus is present. No rations free from organic phosphorus were used, however, and conditions were not favorable for a comparison of organic and inorganic phosphorus, since the rations containing the organic phosphorus compounds were extremely low in calcium, while those containing the inorganic phosphates contained considerable amounts of calcium, in varying proportions to phosphorus, the floats, or rock phosphate, having the greatest advantage in this regard. The retention of phosphorus is much influenced by the presence of calcium in the diet.

Gregersen (1911) conducted a very extensive series of balance experiments with rats, having to do especially with the problem of synthesis of organic phosphorus compounds

from phosphorus-free edestin and inorganic phosphates. The work includes in all 170 balance experiments. The data include no analyses of the bodies of the rats. Gregersen concludes that the organism is able to synthesize organic phosphorus compounds from phosphorus-free organic compounds and phosphates, but is careful not to claim that the inorganic compounds are as efficiently utilized as the organic.

In spite of the phenomenal mass of data the evidence is by no means perfect. The experimental periods are very short; and the capacities of animals to add to and subtract from the very extensive phosphorus reserves in the body, and to effect a redistribution of constituents under stress of necessity are so great that we can not affirm from mere retention experiments of a few days' duration that organic phosphorus synthesis has occurred.

Heubner (1911) conducted feeding experiments in which lecithin appeared much superior to phosphates as a source of phosphorus for growing dogs.

Fingerling (1912) demonstrated that ducks, on a ration which was low in organic phosphorus, but containing potatoes in abundance, produced eggs of normal content of lecithin and nuclein phosphorus. He concludes that the animal organism possesses the ability to cover its requirements for phosphoric acid for the formation of lecithin and nuclein substances just as easily and completely with inorganic phosphates as with organic phosphorus compounds. This conclusion could be justified in so positive a form only by the use of a ration entirely free from organic phosphorus and by demonstrating that the original content of organic phosphorus in the body was maintained without loss, and that the eggs suffered no loss of function.

Abderhalden (1912) shows that dogs maintain nitrogenous equilibrium and retention in balance experiments on products of either acid or enzymatic splitting of proteins, or on a mixture of known amino acids. He expresses the belief that the organism must have prepared for itself all of the building-stones which are specific for phosphatids. Complete carcass analysis experiments alone can settle such points.

Another series of investigations, mostly of recent date,

gives a different aspect to this problem. I have in mind investigations by Röhmann (1902, 1907, 1908), Falta and Noeggerath (1906), Jacob (1906), Knapp (1908), McCollum (1910), Stepp (1911), Osborne and Mendel (1911a, b, 1912a, b, c, & d, 1913), F. G. Hopkins (1912), Hopkins and Neville (1913), and McCollum and Davis (1913a, b). All of these workers, using rats and mice as experimental subjects, have obtained results in this field, which are in general harmonious. Using rations of purified food substances they have obtained considerable amounts of growth, in spite of many failures, with rations which were at least practically free from organic phosphorus compounds and from purins. The maximum normal size was not attained, however, and the character of this growth has not been determined, that is, whether the composition and functions of the body remain normal. These experiments have been more successful with young rats than with old ones, and more successful with rats than with mice.

Osborne and Mendel (1912b) submit a table showing the relative increase in the weight of rats during 30 days' feeding with 22 different plant and animal proteins. With a number of these proteins the live weight was not maintained; with others there was marked increase. Casein and vitellin, both phosphorized proteins, were placed at the head of the list as producing the greatest gain in weight. Inspection of the data, however, does not show a *marked* superiority of phosphorized over phosphorus-free proteins to cause gain in weight during 30 days. The considerable variation in gain in weight in this series of tests must have been due to factors of greater immediate, if not of greater ultimate importance. These experiments, of course, have no direct bearing on the nutritive values of organic phosphorus compounds other than phosphoproteins—the lecithins and nucleins, for instance. The climax of these rat experiments is reached in the discovery that normal growth can not be maintained indefinitely, even with the phosphorized proteins, unless there be present very small amounts of certain unknown compounds which are found in natural foods. Such essential compounds are found in milk and in eggs and other natural foodstuffs of both plant and animal origin.

Lack of such nutrient principles in white rice and patent flour has been shown to be the cause of beriberi, and it is quite probable that similar dietary deficiencies at least predispose to scurvy and pellegra. Funk proposes for these protective compounds the name "vitamines." So far as isolated they are phosphorus-free, dializable, alcohol-soluble compounds of basic reaction, and containing carbon, oxygen, hydrogen and nitrogen.

It therefore seems not at all unlikely that the many demonstrations of superior nutritive value of organic to inorganic phosphorus compounds have been influenced by other beneficial substances occurring in association with them in natural foods, and contained as impurities in these organic phosphorus compounds as isolated and used in nutrition investigations. As to the relative importance of this factor and others we are as yet unprepared to make positive assertions.

Maslow (1913) demonstrated the nutritive superiority of lecithin to inorganic phosphorus and glycerophosphates by feeding experiments with young dogs, the compounds of interest being fed in conjunction with a low-phosphorus diet, and the results being in the nature of estimations of catalase, lipase, diastase, nuclease and amylase in the tissues. Lecithin was shown to have a capacity not characteristic of inorganic phosphorus and glycerophosphates to increase the organic phosphorus content and ferment activity of the tissues. Maslow considers as improbable the possession by dogs of power to synthesize organic phosphorus.

There is also a vast amount of clinical evidence, to which I could refer; much of it flimsy, it is true; but other portions of undoubted value as showing specific effects of lecithin which are not possessed by phosphates, especially the direct contribution of lecithin to the lecithin content of the blood serum and tissues, and the increase of the red blood corpuscles. It is not impossible that contamination with "vitamines" has contributed to these results. It is well known that the lecithin of commerce is not a single pure compound.

In my own work I have in several experiments compared phosphates, hypophosphites, phytin, nucleic acid and

glycerophosphates added to a low-phosphorus basal ration with swine. In one experiment lecithin was used. We have observed no marked specific effects of phytin and nucleic acid from yeast. The phosphates and hypophosphites were not well borne by swine when added to the low-phosphorus basal ration in amounts much less than the equivalent of the phosphorus content of natural foods. Lecithin and glycerophosphates when used in the same way have given no trouble whatever, and the difference in the spirit, appetite, digestion and general behavior of the pigs has been marked.

The muscular tissue produced by the ration containing lecithin was characterized by a very high content of phosphorus, reckoned either as per cent of the total muscle, its protein or its ash.

In the first carcass analysis experiment in which we compared glycerophosphates with the inorganic compounds above mentioned, the difference in the behavior of the animals was especially marked in favor of the pigs which received glycerophosphates. Throughout the tissue analyses there were consistent variations implying specific effects and superior usefulness of the glycerophosphates. In subsequent repetitions of this experiment there has always been manifest in the behavior of the pigs such a difference from others in the ones receiving glycerophosphates as led us to anticipate repetition of the earlier results of tissue analysis, but these have not been uniformly consistent either in sustaining our earlier results, or in demonstrating other truths in a clear-cut fashion.

We are just now completing a combined metabolism and carcass analysis experiment, using some improved methods which we hope will clear up the situation, and are adding a series of enzyme estimations to our program of work on the tissues. We are hopeful that these measures of function will tell us more than the usual chemical analyses of the tissues, regarding the specific effects of the foods.

In the practical conduct of such experiments there are very great difficulties in the way of giving to every ration exactly an even chance. The experimental subjects are not machines. They have very definite preferences and are exceedingly resourceful in evading direct answers to our prob-

lems, especially through redistribution of body constituents, through refusing food, and through eating their own feces, thus making repeated use of the lecithin of the bile residues and availing themselves of the results of the synthetic capacities of the intestinal bacteria. Even when the experimental subjects are so handled that they are unable to eat their own feces they probably get some benefit from the synthesis of organic phosphorus compounds by intestinal bacteria, and this fact introduces a further element of uncertainty into the results of our experiments.

One of our experiences in these experiments suggests that the presence or absence of vitamines has influenced our results. It has often been the case, with rations other than those containing glycerophosphates, that in order to keep the pigs alive it has been necessary to introduce a small amount of corn into the ration. The improvement was always decided. Was this result due to so-called vitamines in the corn? At these times we were unable to get the pigs into good condition by the addition to the ration of corn oil, mangel wurzels, potassium citrate, calcium carbonate or soda. The basal ration was composed of pearl hominy, wheat gluten, blood albumin and corn bran.

It is my feeling that the character of the evidence does not warrant final conclusions in regard to this problem. We are unable to say whether the lack of harmony in results with dogs, rats and mice is due to differences in the nutritive processes of these animals, or to differences in the purity of the organic phosphorus compounds used, or to ill-considered or incomplete experimental methods. I believe, therefore, that we should regard the problem as an open question.

The problem now seems to take the form of a question as to whether we shall regard organic phosphorus compounds as of superior nutritive value because of the chemical relationship of their phosphoric acid or because of the presence of other unknown substances of value associated with them in natural foods.

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The Theory of Antagonism of Salts and Its Significance in Soil Studies

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Even the casual observer cannot but have been duly impressed with the kaleidoscopic movements of profound scientific principles into the domain of agriculture in recent years. But he whose labors have made him a participant in those movements must have been more than impressed with the results of truly scientific research in agriculture. It is difficult to see how one in such a position could fail to become fascinated with the striking revelations flowing from his own efforts and those of his fellows; how he could escape the enthusiastic interest born of a studious observation of the nice correlation between the forces of nature as they affect the welfare of man, animals, and plants. But of all such discoveries and observations it is the writer's opinion that none is invested with greater attractiveness, none so richly steeped in and adorned with scientific beauty, as the recent epoch-making discoveries in the realm of the role of salts in the mechanism of life.

To the keen intellect of Loeb we owe the modern biological conception of physiologically balanced solutions, and largely also the idea of antagonism between salts upon which that conception is based. By the antagonism between salts we mean the power of one or more salts to prevent the toxic action to living matter of one or more other salts. We thus look upon sea water and blood as natural balanced solutions in which the salts are so proportioned as to prevent the toxic effect, to the organism living in or containing them, of any of their components, alone, at the same concentrations. To illustrate, Loeb has found that a solution of sodium chlorid of the same concentration as that of sea water was quickly toxic to many animals, but when small quantities of calcium chlorid were used, or even better also small quantities of potassium chlorid, the animals could live and function normally for considerable periods of time. Osterhout has likewise shown this conception of antagonism

of salts and physiologically balanced solutions to hold in the plant kingdom, and Loew has contributed some valuable information of interest to agriculture on the protective action of calcium against magnesium for plants.

The mechanism of antagonism which has recently been the subject of some striking investigations is not yet fully understood. Nor is it desirable nor possible here to enter into a discussion of it. Suffice it for the purpose of this paper to state, that the general theory on the mechanism of antagonism consists of the idea that salts in solution possess powers, more or less pronounced, of hindering each other from permeating the cell walls of living cells. Moreover, the evidence in hand appears to support strongly this idea; but just how one salt or its component ions prevent the entrance of other salts or their component ions into the cell still remains a secret for future research to reveal.

The writer wishes to present some remarks on the relation of the conception of antagonism of salts to the problems of agriculture, based upon his own work as well as upon the experiments of others. The necessary brevity of this paper precludes the possibility of describing experimental work in detail, and of giving a discussion to this important subject which will be comprehensive. It is only my purpose to state briefly the salient points as they present themselves to me which are involved in that aspect of the subject which is of direct interest to us.

The branches of agricultural work in which the principle of antagonism of salts can at once be seen to have application are plant physiology, soil bacteriology, and perhaps in a minor way, plant pathology, dairy bacteriology, and entomology. My own work has been in the first two fields in which indeed the best promise for striking results is to be found. I shall first attempt a discussion of these singly.

Since Osterhout's work so strikingly confirmed for the realm of plant life what Loeb had so ingeniously discovered for the animal kingdom with respect to the role of salts, attention has been given to the possible application of the theory of the antagonism of salts to the alkali problem in soils. It seemed reasonable to suppose that if concentrations of salts which behaved in a toxic manner to plant growth,

for reasons other than those involved in marked changes of osmotic pressure, could be made innocuous either partly or wholly by the addition of salts with powers to antagonize them and prevent their toxicity, we would possess an important weapon in our campaign for the reclamation of alkali soils. Osterhout's experiments were, however, carried out in solution cultures, and since recent experience has so amply shown that the application of results thus obtained to soil cultures was unjustified in most cases, I thought it desirable to start experiments with alkali salts in soil cultures. These were carried out for the purpose of ascertaining if the principle involved in Osterhout's results could in general be applied to soils; and secondly, for determining to what extent antagonism between anions existed. Since most of our alkali salts consist of sodium compounds, this latter point was of particular interest, and only very scant and scarcely pertinent information on this point, even in its general aspects, has thus far been gleaned.

Accordingly, an experiment involving the three common constituents of alkali soils, namely, sodium chlorid, sulphate and carbonate, was instituted in which a larger number of combinations of the salts was employed. The attempt was made to show whether a given concentration of any of these salts which had previously been proven toxic for barley could be made less toxic by the addition of the other salts, even at concentrations at which they were themselves toxic. Without giving the tables of data obtained in these experiments, I may cite the following results which give support to the efficacy of the antagonism of salts in soil cultures, both as between kations and anions.

A stiff clay adobe soil of poor physical condition in eight-inch paraffined pots was employed, and barley was the crop grown. The salts were added as percentages of the dry weight of the soil. Moisture conditions were maintained as nearly as possible at the optimum. When plants were grown in duplicate pots containing a concentration of sodium chlorid equivalent to .25%, the dry weights of barley tops obtained were equal to 4.5 and 3.0 gm., respectively, and the dry weight of the roots in the same pots were equivalent, respectively, to .40 and .25 gm. When, however, to each of

two pots, similarly treated to those above, was added .12% of sodium carbonate the yields of dry matter in the tops, were, respectively, 6.5 and 5.5 gm., and the corresponding dry weights of roots were .25 and .10 gm.

Where a smaller but still toxic concentration of sodium chlorid was employed similar results were obtained. For example, in two pots containing .1% of sodium chlorid the yields of dry matter for tops were, respectively, 6.0 and 6.2 gm., the weights of roots corresponding being equal to .70 and .50 gm., respectively. When, however, there was added to each of two pots similarly treated to the foregoing .15% of sodium carbonate the yields of dry matter for the tops were, respectively, 7.1 and 8.2 gm., and the dry matter of the roots was equivalent in each to .3 gm.

The results obtained in combinations of sodium carbonate and sodium sulphate, however, were different, though antagonisms between the salts was manifest. For example, when sodium carbonate alone at a concentration of .15% of the dry weight of the soil was used, the yields of the tops in duplicate pots were, respectively, 7.5 and 7.3 gm., and the corresponding weights of roots were .7 and 1.10 gm. When to the same concentration of sodium carbonate was added .1% sodium sulphate, there was a depression in the yield so that duplicate pots yielded, respectively, in the tops 4.0 and 6.6 gm., and in the roots 1.2 and .6 gm. It is interesting to note, however, that marked improvement was obtained in the growth of the barley plants in pots to which twice the quantity of sodium sulphate used in the last-mentioned pots was added to the sodium carbonate. Thus, yields of 5.5 and 7.0 gm. of the tops, respectively, and 1.2 and .9 gm. for the corresponding weights of the roots were obtained.

Beyond a doubt the efficacy of antagonism between salts in improving soil conditions for plant growth is amply proven by the data just cited. It is even more interesting to note above that the antagonism in question obtains between anions, a fact in proof of which the data to date is very scant. We went further, however, in our experimental work in an attempt to show the efficacy of antagonism between kations in support of other work and for the demon-

stration of its application to soil cultures in a large way. Accordingly, we arranged to study the antagonisms between kations by employing salts with the same anions. An example will suffice here to illustrate the work done and the results obtained.

When a concentration of .4% of sodium sulphate was employed the yields of tops of barley in duplicate pots were 4.3 and 4.5 gm., and of root .35 and .4 gm. When 1% of calcium sulphate was added to the .4% of sodium sulphate the yield was much depressed and equalled 1.8 and 2.1 gm., respectively, for tops and .4 and .3 gm. for the roots. When .20% of calcium sulphate was added to .4% of sodium sulphate the yields of tops were 6.2 and 5.6 gm., respectively, and of roots .7 and .3 gm. When .3% of calcium sulphate was added to .4% of sodium sulphate the yields in duplicate were 6.9 and 6.0 gm., respectively, for the tops and .7 and 1.00 gm. for the roots. Further additions of calcium sulphate to the sodium sulphate depressed the yields.

We see here, therefore, not only marked improvement in the soil as a medium for barley through additions of calcium sulphate to a toxic quantity of sodium sulphate, thus showing antagonism between kations, but we must also note the marked effect produced on the root growth of large additions of calcium sulphate and that large amounts of the antagonizing salt in this case are effective, whereas small amounts may only serve to increase the toxicity of the sodium sulphate.

Enough data have been cited above from our experiments to indicate a promising means of combating chemically the toxic effects of alkali salts in lands where they have accumulated to a detrimental degree. It appears to the writer entirely possible that in the near future we shall be able to employ in the manner suggested chemical means for alkali reclamation, not only as an important and adequate means by itself but also in conjunction with more expensive methods of a different nature, which alone may be inadequate to cope with the problem.

In further support of the data and discussion just presented a few remarks may be added anent similar lines of work which I have carried out on the soil flora. Since the

soil bacteria are an all-important factor in the preparation of available food for plants in soils, nothing which relates to their well-being and activities in the soil can be foreign to the subject of soil fertility. Indeed, it therefore seems necessary in the light of modern advances in agricultural science to consider always in a study of soil treatment not only the results of such treatment on plant growth on the soils in question but also on the soil flora.

Preliminary experiments, which have been reported elsewhere, indicated that .2% of sodium chlorid and .9% of sodium sulphate, based on the dry weight of the soil, were toxic to the mixed ammonification flora in a light sandy soil from Anaheim, California. In the presence of .2% sodium chlorid alone in a soil culture only 30.73 mgs. of ammonia nitrogen were produced. When, however, the culture contained in addition to this amount .3% sodium sulphate 37.10 mgs. of ammonia nitrogen were produced; or in other words, the increase of the total alkali content from .2% to .5% so far from decreasing the ammonifying power of the soil, actually and markedly increased it. Similarly the addition of .7% sodium carbonate to the same toxic concentration of sodium chlorid was instrumental in considerably more than tripling the amount of ammonia nitrogen produced, for it rose from 22.05 mgs. in the cultures with sodium chlorid alone to 70.70 mgs. where the carbonate had been added. When sodium sulphate at the toxic concentration of .9% of the dry weight of the soil was employed in a soil culture, the ammonifying flora produced only 28.59 mgs. of ammonia nitrogen. When, however, the total alkali content of similar cultures was raised to 1.5% by the addition of .6% sodium carbonate the amount of ammonia nitrogen produced was equivalent to 45.38 mgs.

No more striking evidence of the validity of the principle of antagonism of salts and also of the antagonism between anions need be presented. It should be added, of course, that the figures given are only a few isolated examples which are the most striking, but that there is to be found in the complete data of the experiments ample evidence in their support to satisfy the most skeptical.

In the case of the nitrifying flora of soils similar results

were obtained. Marked improvement was wrought in soil cultures by the addition of one toxic alkali salt to another. For example, the addition of .05% sodium sulphate to a soil culture containing .2% sodium chlorid increased the nitrifying power of the same soil by 40%, and improvement continued with even larger additions of sodium sulphate up to .15%.

Further illustrations of the effectiveness of antagonism of salts in the improvement of a soil's nitrifying power are as follows: Sodium carbonate to the extent of .05% of the dry weight of the soil was definitely toxic, but when .1% sodium sulphate was added the nitrifying power was increased by 35%. When, further, sodium sulphate was used in toxic concentration, as for example, .35%, the addition to it of .05% sodium carbonate (itself a toxic concentration) increased the nitrifying power of the soil by approximately 25% over that of the same soil containing only the amount of sodium sulphate mentioned.

GENERAL REMARKS.

Enough examples of the effectiveness of the antagonism of salts as regards both the higher plants and the soil bacteria are at hand to render the theory of marked interest scientifically and of great practical significance. The writer is now testing other phases of the problem in the greenhouse and laboratory, and is carrying his researches into the field where experiments can be carried out on a more comprehensive and practically more significant scale. That results will thus be secured which will prove a potent instrument in the management of alkali soils, I think, can justifiably be claimed on the basis of the data just discussed.

Considered in the large the subject of antagonism of salts appears to be becoming more and more important as the researches in that field rapidly increase in number and comprehensiveness; and that fact, taken together with the fascinating nature of the work from the scientific standpoint, promises to render it one of the most fruitful fields of bona fide research in the vastly complicated and intensely

interesting domain of agricultural science. For the plant physiologist and soils specialist in particular, the study of the role of salts in life processes will, in my opinion, continue for many years to come to be one of the most attractive fields of research of the many that are open to them.

The Relation of Ecology to Agriculture

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The subject of Ecology has many practical applications, as has recently been shown by Coulter in a paper on "Increasing land population." The forester perhaps more than anyone else, in practical work, has recognized the importance of this subject in considering the distribution of forest trees. Such factors as humidity, precipitation, mineral matter in the soil, water and temperature of the soil, the chemical and physical properties, the living and non-living covering of the soil, are all considered by the forester as having a most vittal relation to the kind of tree growth.

The botanist has been slow to take up the important relations of plants as applied to practical problems of the farm and garden. He cannot complain because many practical aspects of the subject of botany have been taken up by men who have not been trained primarily as botanists. We have been slow to exert ourselves because the subject seemed practical. We have, I fear, not had the viewpoint of the agronomist and horticulturist. It appears to me that the botanist should recognize and fraternize more with practical men. In other words, we should have an intelligent sympathy with all of the operations of the farm and garden.

It seems to me that there is a large and useful field in the line of agricultural ecology. The larger problems have to do with systems of cropping. Dr. Coulter has well said "If natural plant associations teach us anything it is that for each kind of plant there are optimum conditions in which the yield is largest. Therefore, a poor field of corn may be an ideal field for some other crop. Ecology will presently develop a group of trained men who can diagnose conditions for plants and can determine conditions for any area, the plant of maximum yield." Why not grow two or three crops on the same soil at the same time, as suggested by Dr. Coulter. To do this, however, we will need trained ecologists, men who know more than the chemistry and

physics of the soil. There are, in fact, most complex relations for the crop ecologist to determine.

The crop ecologist should know more about the root systems of cultivated plants. Many investigations have been made on the roots of corn and many of the other cereals. Still our knowledge is very meager for many of the cultivated plants. What do we know about such crops as rape, and root crops, and especially of weeds? What do we know of the roots of weeds and crop interference? What do we know of the development of roots when two crops are grown together like corn and rape, or of the soy bean, cow pea, and corn? The line of work suggested by Drs. Lipman, Lyon and Bizzell on the associative growth of legumes and non-legumes and the increase in the amount of nitrogen in the non-legumes,[1] is an important one.

The forester and ecologist use the terms tolerant and intolerant plants. Many farmers claim that the roots of the cocklebur prevent or retard the growth of clover. This opinion has been partially verified by an experiment made by E. B. Watson[2] in the writer's laboratory. It was found the the cocklebur does inhibit the germination of clover seed and checks the growth of the clover plant. Prof. L. R. Jones and his assistants have found that the butternut retards the development of the shrubby cinquefoil, which is a troublesome weed in Vermont. May not the growing of certain agricultural crops inhibit the growth of certain types of weeds? The writer has long thought that the partial benefits of the growing of sorghum on quack grass land may in part account for the value of this plant in subduing quack grass; shading of the ground, of course, has a deterrent effect.

Those who believe that toxins are produced by certain roots certainly have some good grounds for their belief. This theory has been very well expressed by Dr. Cowles:

"Very recently it has been shown that the roots of certain plants excrete substances which impede further root activity. If this phenomenon proves to be general, as now

[1]New Jersey Agrl. Exp. Sta. Bul. 253; Cornell Agrl. Exp. Sta. Bul. 294; Jour. Amer. Soc. Agron. 5, p. 65.

[2]Proc. Ia. Acad. Sci.

seems likely, the invasion of new soil areas by roots may make possible their escape from the substance which they give off or which arise by subsequent decay. Even in the case of cultivated crops, it is probable that fertilizers are of less value as sources of plant food than in their action upon soil constituents and in counteracting the noxious effect of root excreta or of decaying vegetation. Certain root enzymes are oxidizing agents of much importance and assist in the destruction of the deleterious soil compounds; however, when these compounds are present in excess, the oxidizing action becomes lessened and the addition of nitrates and of other fertilizer salts is of great value. Farmers have long believed that fields occasionally should lie fallow; the advantage therefrom would appear to be in the facilitation of the oxidation and the removal of deleterious substances. It seems likely that substances given off by plants of a particular species often are more injurious to plants of their own kind than to plants of other species, a fact that may help explain the value of crop rotation."

We should not, however, overlook the other side of the question which has been tersely stated by Hopkins,[1] who does not overlook the importance of fungus disease as a factor in crop production. The fixation of nitrogen by some plants like the legumes; the acquisition of carbon, oxygen, and hydrogen by photosynthesis and the need of certain mineral constituents, are supported by all experimental work. Along the same line, Dr. Edward J. Russell in a discussion of the soil in relation to plant growth, states that the intrinsic properties of the soil are due to the nature of its constituent properties, but the extrinsic properties impressed by topographical climatic factors. Russell[2] concludes, with Danberry, that the often quoted theory of DeCandolle was not justified except, perhaps, in the case of the common European weed *Euphorbia lathyris*. There may, however, be a transient effect. The results of Pickering's work[3] on the effect of grass on apple trees is quoted to substantiate this

[1]Soil Fertility and Permanent Agr culture, p. 319.
[2]Soil Conditions and Plant Growth, p. 120.
[3]Rept. of the Woburn Exp. Fruit Farm, 3, p. 13.

theory. This is in line with the work quoted here on cocklebur and clover, and the butternut and shrubby cinquefoil. The work of Livingston,[1] et al., should be consulted in this connection. It is a question of importance for the agricultural ecologist to determine the proper plant associations.

Recently Prof. H. L. Bolley[2] has announced that soil sanitation is an important matter for the agriculturist to consider, that failure of crops is caused by the presence of parasitic organisms in the soil. There is certainly some evidence to show that this is true, in part, for certain crops. He concludes as follows:

"My experience with cereal crops with reference to the application of fertilizers, the trial of varieties, experiments in seed selection, seed breeding and seed treatment, and seed purification furnish data which will allow me to say that I have no fear that all will eventually agree that sanitary considerations with reference to the characteristics of parasitic diseases which are now quite commonly resident in the seed and the soil will yet form the essential basis for the proper management of crops in rotation in series, and the same considerations will largely govern the type of tillage and the manner of handling waste materials on the farm, particularly farm manures. Further, aside from the matter of variety as to food value, the efforts of agriculturists and agronomists with reference to cereal cropping will, in the future, give primary consideration to the selection of seed for sowing purposes, based directly upon its powers of resistance to disease."

It seems to me it is the province of the ecologist to study these crop relations from an ecological standpoint, so that the maximum production may be produced at all times. More study should be made of the light relations of plants. The crop ecologist certainly should know what the optimum light requirements are for such a crop as corn, and how such plants as rape or legumes will do in fields with corn. It is important to know the solar energy required by the

[1]Further Studies on the Properties of Unproductive Soils. U. S. Dept. Agrl. Bur. Soil . Bul. 36.

[2]Science N. S. 38, p. 248; Hopkins, Science N. S. 38, p. 479.

agricultural plants. The paper by H. L. Shantz[1] is highly suggestive of good work that can be done along the line of crop ecology. It involves the distance of the planting of corn, and the crop to grow with it to bring the greatest returns, taking into consideration the destruction of weeds by the planting of another crop.

Much emphasis has been put on soil surveys by the National Government and some of the states. These studies have usually been made from the chemical and physical standpoint, and little attention has been given to the plant covering. The plant covering is a sensitive barometer. I prize highly the most exhaustive researches of the chemist and the soil physicist, but the chemical and physical work should coöperate with the botanists and zoologists. Let me illustrate by using a few typical cases. The presence of salt grass (*Distichlis maritima*) indicates the presence of alkali; the presence of *Zygadenus elegans* in western Wisconsin indicates the presence of magnesium limestone; the white oak and shell bark hickory universally occur on upland clay soil, the black walnut on alluvial soil, *Rumex acetosella* on gravelly and sandy and acid soil. We do not know the limits of the amount of different constituents and the growth of these weedy plants.

This limit has, however, been shown for some plants. Kearney[2] states that *Distichlis spicata* can grow in soil where 1.5 per cent of the dry weight consists of alkali; sugar beets will grow in the presence of as much as 2.5 per cent, but the roots produced are small and the sugar content low, and the ash content of the juice is too high. In soils holding not more than 1 per cent of alkali salts, sugar beets, western wheat grass, awnless brome grass, and tall meadow oat grass will make fair returns. Western wheat grass, meadow fescue and a few others will make good crops where the alkali is not more than 6.8 per cent. Dr. Lougbridge[2] has recently shown that certain species of Eucalyptus will grow in alkali up to certain limits; a per-

[1]U. S. Dept. of Agr., Bul. Bur. Pl. Ind., 279.
[2]U. S. Dept. Agr. Farmers' Bull. 446, p. 13.
[3]California Exp. Sta. Bul. 225.

centage of .07 for many of the species, and .09 for *E. rudis* and *E. rostrata* has an inhibiting effect.

The water requirement of various cultivated plants is an important matter, and that this is profoundly affected by the conditions of the atmosphere has been shown by papers of Briggs and Shantz, and here again are opportunities for the ecologist. The relation of weed growths and the amount of water which should be utilized by the growing crop is another matter of importance. Much of the loss of crops is, no doubt, caused by this enormous loss of water, due to the growth of weeds.

The statistical method used by Clements and his co-workers is a most useful line of work for general field studies of our different soil types. Such studies as the work of Shantz on the mesa region east of Pike's Peak, and the Harvey studies of a prairie region, indicate lines of work that are applicable to a study of the vegetation and soil types. Of course, we must take into account that cultivation has greatly modified the appearance of plants. It is possible, however, by making a study of the ruderal plants to determine something more specific. It has been pointed out by Daniels[1] that anthrophytic vegetation is either directly under human control or consists of species which grow under a great variety of conditions and in a wide range of soils, and does not therefore fall readily into distinct societies. This is true only in part. Some of the weeds or plants of cultivation are associated with certain plants and in certain soil types. In an Iowa blue grass pasture (*Pascuales*), the blue grass is invariably associated with the white clover (*Trifolium repens*); in some soils the blue vervain (*Verbena stricta*) is a common associate, the dandelion (*Taraxacum officinale*) and the squirrel-tail grass (*Hordeum jubatum*). In the upland gravelly or sandy soils sheep sorrel (*Rumex acetosella*) and the prostrate vervain (*Verbena bracteosa*) are common associates. In the timothy meadow (*Pratensis phleoides*) the two white weeds (*Erigeron annuus* and *E. strigosus*), pepper grass (*Lepidium apetalum*) and red clover (*Trifolium pratense*) are abundant.

[1]Univ. of Mo. Studies. Science Series, 1, p. 67.

The relation of the biota to its environment is important to the agriculturist. The splendid and unique results obtained by Adams and Ruthven for northern Michigan are of especial interest in this connection.

Brenchley[1] has made an interesting study of the weeds of arable land in relation to the soils on which they grow. The work was done chiefly in the geological series of rocks between Harpenden and Bedford. The weeds of the region were collected and placed under five divisions as follows: (1) dominant, (2) sub-dominant, (3) very generally distributed, (4) occasional, (5) scarce or rare. The paper does not, however, give an exact analysis of the soil. The results of this preliminary investigation show that certain weeds may be regarded as dominant for certain soils. The *Brassica arvensis* is dominant on all kinds of soil. The *Cirsium arvense* is usually dominant on the lighter types of soil. The *Chenopodium album* is characteristic of light sandy soil and frequent on clay, *Agropyron repens* occurs chiefly on lighter types of soil, and *Rumex acetosella* is characteristic of acid soils. This author found that the nature of the soil plays an important part in determining the local weed flora; the character of the crop is a matter of indifference except the seed crops. Lime is injurious to mayweed and it is soon destroyed by competition with crops. Weeds, as the investigations show, are not generally confined to special crops, except in seed crops certain weeds are constant.

It has appeared to me that something might be determined in a quantitative way concerning the weeds of crops in Iowa. Using the same terms that Brenchley does, the following may serve to illustrate: *Brassica arvensis* is a dominant weed in grain fields; *Setaria viridis* and *Polygonum Pennsylvanicum* are dominant weeds in corn fields; *Ambrosia artemisiaefolia, Verbena stricta,* and *Hordeum jubatum* are dominant in pastures; *Silene antirrhina, Rumex acetosella* are dominant in sandy and gravelly fields.

[1]Annals af Botany 25 p. 155; 26, pp. 95-109.

Variation in the Tongue Color of Jersey Cattle[1]

By Raymond Pearl,

Maine Experiment Station.

Amongst cattle of the Jersey breed a majority of individuals have heavily pigmented tongues, commonly described by the breeders as "black." The remaining minority of individuals have tongues either not at all or only slightly pigmented. The "black tongue" is regarded as a characteristic feature of the breed and is esteemed on that account by the breeder. There is, however, no severe discrimination against white or light tongues, since some of the well-known animals of the breed[2] have had such tongues. Examples here are, amongst bulls, Flora's Lanison (43813), Valentine's Oonan (68076), Oonan's Count (57479), Ida's Landseer (17745) and Inez' Stoke Pogis (511942). Among the cows Yolette of Sheomet (208614), Miss Nancy of Bleak House (230792), Lass 38th of Hood Farm (223628), for example, are white tongued animals with very high milking records.

The present study was undertaken in connection with an investigation now under way regarding the inheritance of tongue color in the Jerseys. The data used were derived from the Herd Register of the American Jersey Cattle Club. In the rules of the Club one requirement for registration is that the color of the animal's tongue shall be stated. This requirement is not always enforced. In from 1 to 2 per cent of cases at the present time no record of the tongue is made. Formerly the number of omissions was larger.

Respecting the accuracy of the records it must be recognized at the outstart that they are herd book records, and on that account are subject to some errors and open to some criticisms. The initial record is made by the breeder. He is liable to make mistakes, particularly since no standard for

[1] Papers from the Biological Laboratory of the Maine Agricultural Experiment Station, No. 55.

[2] Here and throughout the paper it will be understood that reference is made to the breed of Jersey cattle in America; or more specifically to animals registered in the Herd Register of the American Jersey Cattle Club.

descriptive reference is furnished him. In consequence not all breeders would describe the same tongue in the same terms. What one man would record as "black" another would call "dark," or "blue," or "smoky," or "dusky," etc. This, however, should not be regarded as a more serious defect in the records than it really is. As will presently appear, it is possible, with a considerable degree of confidence, to group all these varying breeders' descriptions into certain broad categories. There is little chance of actual fraud so far as concerns this particular character tongue color, because it would shortly be discovered in the transfers. A man could not, in the long run, sell white-tongued animals which had been originally registered as black. There is, however, one real, though small, source of error, which can not well be avoided since its basis is biological. It arises from the fact that sometimes the pigmentation is retarded in its development, with the result that an animal which, as a calf, was registered with a white tongue, comes in adult life to have a pigmented tongue. I am informed by a breeder of long experience that this rather infrequently occurs in Guernsey cattle (in which breed black tongue and muzzle is not considered desirable). It is his opinion that a similar change may, in rare cases, occur in Jerseys, but that it cannot be frequent enough to affect sensibly any conclusions drawn from the herd-book records of tongue color.

The primary objects of the present study were these:

1. To find the recorded distribution of tongue color in a sufficiently large random sample of Jersey cattle at the present time.

2. To determine whether any secular change is going on in the proportions of animals exhibiting the different tongue colors.

3. To find whether there are any sexual differences in the distribution of tongue color.

The data used in this study were taken from two volumes (Vol. XLI and LXXVII) of the Herd Register. Vol. XLI includes registrations made in 1893, and Vol. LXXVII registrations made in 1913. In neither case does the volume include all the registrations of the year. These furnish two

samples twenty years apart in point of time. In the case of Vol. LXXVII the tongue color of every animal recorded in the volume, 2,500 bulls and 4,950 cows, was extracted and put in the form of a frequency distribution as shown in Table 2. In the case of Vol. XLI every animal was dealt with similarly except, on the one hand, those whose records had been cancelled by the Secretary of the American Jersey Cattle Club, and on the other hand some 150 cows at the end of the volume, which, through an oversight, were not included. In both cases the distributions represent a random sample of the animals of the breed *registered* during the periods specified. The order of registration of animals is the order of receipt of duly qualified entry blanks by the Secretary of the Club. It is in no way related to the tongue color of the animals. The data were extracted from the registry books by an assistant, Miss Anna B. Perkins, and subsequently checked as to accuracy by the writer.

RESULTS.

The raw distributions, representing the data exactly as recorded in the Herd Book, are given in Table 1 (for 1893) and Table 2 (for 1913).

TABLE 1.—SHOWING THE RECORDED TONGUE COLOR OF REGISTERED JERSEY CATTLE IN 1893.

Color.	*Bulls.*		*Cows.*		*Total number.*	*Total Per cent.*
	Number.	*Per cent.*	*Number.*	*Per cent.*		
Black	1394	76.30	3103	70.11	4497	71.92
White	259	14.18	890	20.11	1149	18.37
Dark	84	4.60	155	3.50	239	3.82
Light	48	2.63	168	3.80	216	3.45
Red	7	.39	20	.45	27	.43
Slate	13	.71	37	.84	50	.80
Buff	1	.05	......	....	1	.02
Brown	4	.22	4	.09	8	.13
Gray	1	.05	7	.16	8	.13
Yellow	1	.05	1	.02	2	.03
Pink	2	.11	9	.20	11	.17
Drab	......	....	1	.02	1	.02
Smoky	......	....	3	.07	3	.05
Dusky	......	....	1	.02	1	.02
Lemon	......	....	1	.02	1	.02
White and black	......	....	11	.25	11	.17
Black and white	5	.27	......	....	5	.08
Spotted	4	.22	......	....	4	.06
Mottled	3	.17	2	.05	5	.08
Striped	......	....	1	.02	1	.02
Partly white	1	.05	......	....	1	.02
Partly black	......	....	1	.02	1	.02
White tip to black	......	....	4	.09	4	.06
Black tip to white	......	....	7	.16	7	.11
Not recorded	161	....	503	....	664	....
Total without unrecorded*	1827	100.00	4426	100.00	6253	100.00
Grand total	1988	....	4929	....	6917	....

*All percentages are reckoned as of this total.

TABLE 2.—SHOWING THE RECORDED TONGUE COLOR OF REGISTERED JERSEY CATTLE IN 1913.

Color.	*Bulls.*		*Cows.*		*Total Number.*	*Total Per cent.*
	Number.	*Per cent.*	*Number.*	*Per cent.*		
Black	1911	77.62	3591	73.78	5502	75.07
White	318	12.92	781	16.05	1099	15.00
Dark	107	4.35	224	4.60	331	4.52
Light	50	2.03	107	2.20	157	2.14
Red	3	.12	9	.18	12	.17
Slate	16	.65	46	.94	62	.85
Brown	6	.24	8	.16	14	.19
Gray	10	.41	11	.23	21	.29
Blue	7	.28	11	.23	18	.25
Whitish	1	.04	......	....	1	.01
Fawn	1	.04	......	....	1	.01
Clay colored	1	.04	......	....	1	.01
Pink	11	.45	11	.23	22	.30
Drab	1	.04	2	.04	3	.04
Lead colored	......	....	1	.02	1	.01
Orange	......	....	1	.02	1	.01
Chocolate	......	....	1	.02	1	.01
Smoky	2	.08	3	.06	5	.07
Black and white	5	.20	32	.66	37	.50
Spotted	......	....	12	.25	12	.17
Mottled	5	.20	11	.23	16	.22
Partly white	1	.04	1	.02	2	.03
White tip to black	4	.17	1	.02	5	.07
Black tip to white	......	....	3	.06	3	.04
Black tip to mottled	1	.04	......	....	1	.01
Dark edge to white	1	.04	......	....	1	.01
Not recorded	38	....	83	....	121	....
Total without unrecorded	2462	100.00	4867	100.00	7329	100.00
Grand total	2500	....	4950	....	7450	....

From these tables the following points are at once apparent:

1. At the present time something over 75 per cent of registered Jersey cattle have black tongues.

2. In the last twenty years the proportion of black tongued individuals has increased slightly. The amount of this increase is, in the males, about 1 per cent and in the females nearly 4 per cent.

3. A higher proportion of males than of females have black tongues. This difference between the sexes was somewhat larger twenty years ago than it is now.

The lack of a definite standard of description is evidently not a serious one. Over 95 per cent of the animals are put into one or another of the four categories, "black," "white," "dark," "light." In the case of the remaining long list of categories it is not difficult to distribute the animals into the three fundamental classes, pigmented, non-pigmented and spotted. The following list shows all of the categories arranged on this basis:

Pigmented.	*Non-pigmented.*	*Spotted.*
Black	White	White and black.
Dark	Light	Black and white.
Slate	Red	Spotted.
Gray	Whitish	Mottled.
Blue	Fawn	Partly white.
Clay colored	Pink	White tip to black.
Drab	Orange	Black tip to white.
Lead colored	Buff	Black tip to mottle.
Chocolate	Yellow	Dark edge to white.
Smoky	Lemon	Partly black.
Brown		Striped.

It should be said that the above classification is based on the black pigment. In addition to this is to be taken into account the color due to dermal fat deposition (giving a yellow coloration). This may be present as a factor in the coloration either in the absence or the presence of the black pigment. This probably explains such designations as brown, fawn, buff, lemon and chocolate.

Rearranging the data according to the above classification gives the results set forth in Table 3:

TABLE 3.—SHOWING THE NATURE OF THE TONGUE PIGMENTATION OF JERSEY CATTLE IN 1893 AND 1913.

Pigmentation	*Bulls.*		*Cows.*		*Number.*
	Number.	*Per cent.*	*Number.*	*Per cent.*	
Series of 1893					
Pigmented..........	1496	81.88	3311	74.81	4807
Non-pigmented.......	318	17.41	1089	24.60	1407
Spotted..............	13	.71	26	.59	39
Totals...........	1827	100.00	4426	100.00	6253
Series of 1913					
Pigmented...........	2061	83.71	3898	80.09	5959
Non-pigmented.......	384	15.60	909	18.58	1293
Spotted..............	17	.69	60	1.24	77
Totals...........	2462	100.00	4867	100.00	7329

It is seen from this table that the proportion of animals with non-pigmented tongues is distinctly higher among cows than among bulls. The difference between the sexes in this regard is, however, apparently becoming less. In 1893 the difference was over 7 per cent. Now it is a little less than half that amount. In both bulls and cows the proportion of non-pigmented animals has decreased in the twenty years. The explanation of these relations is, without any doubt, to be found in the history of the "fashion" in tongue color in the Jersey breed. Twenty years ago there was virtually no selection on the basis of tongue color, in the registration of Jersey heifers. That is, the color of her tongue had practically no weight in determining whether any particular heifer calf should or should not be registered. In the case of bulls, however, the tongue color was at that time a factor of some importance. Other things being equal the black tongued bull calf would be registered in preference to the white tongued one. Since only a fraction (roughly, probably about one-half) of all bull calves born are ever registered, a more or less stringent selection always obtains. During the period from about 1895 to

1905 the preference for black tongues was strong. Tongue color was a significant factor in the selection of a bull. Since the latter date the pendulum has been swinging the other way, until now it appears that it is practically a matter of indifference, both concerning registration or sale, whether an animal has a black or a white tongue.[8]

There would seem to be little doubt that the increase in the proportion of pigmented individuals in 1913 over 1893 is in the main a result of the wave of insistence on the importance of tongue color. More pigmented tongues are actually being produced now, fundamentally for the reason that there are more black-tongue genes in the general Jersey population than there were then.

The ratio of pigmented to non-pigmented in the cows of 1893 is of a good deal of interest. As we have seen above these cows may be taken as a random sample of a population, in the breeding of which virtually no selection for tongue color had been practiced. The number of spotted tongues is so small (0.6 per cent) as to indicate that they do not represent a distinct genetic class, but rather are somatic variations from pigmented and non-pigmented. Distributing these spotted individuals equally between the two other classes we have the following results:

	Pigmented.	*Non-pigmented.*
Observed	3324 (75.105%)	1102 (24.895%).
Expected on the basis of a 3 : 1 ratio of pigmented to non-pigmented	3319.5 (75%)	1106.5 (25%).

This is an extraordinarily close agreement. It suggests at once that we have here a simple case of Mendelian inheritance, in which pigmented tongue is the dominant character and non-pigmented the recessive. This matter is being studied further in this laboratory at the present time by analysis of individual matings. The failure of the bulls of 1893, or the general population of 1913, to show the simple 3 : 1 ratio cannot be taken as evidence against the sug-

[8]These statements represent the conclusions reached after discussion of this point with a number of active and well-informed Jersey breeders, particularly Mr. H. M. Tucker of Canton, Maine.

gested Mendelian inheritance of the characters, because of selection in the one case, and the change in the genetic constitution together with selection in the other case.[4]

[4] Since the above was written further studies indicate that tongue color hereditarily depends upon two separate factors which show partial coupling on a 3:1:1:3 basis. A detailed discussion of the data regarding inheritance of the characters will be published later.

What Massachusetts Has Accomplished eor Science in Her Fight Against the Gypsy and Brown Tail Moths

By F. W. Rane,

Massachusetts State Forester.

The pages of universal history may be scanned in vain for a record of a war between nations which has not resulted in new inventions or discoveries that have served to advance civilization, discoveries that were made possible by the exigencies of the times. This progressive knowledge has become the bulwark of the development and stability of the nations of the earth. In her war against the gypsy and brown-tail moths, the experience of Massachusetts has not been at variance with past history.

Throughout the long and costly struggle to save our forest and shade trees from being completely destroyed by these voracious insects, inventive minds, as in other wars, have been studiously engaged in developing better and more destructive methods of warfare, from which a permanent addition to science has resulted.

The Commonwealth of Massachusetts has placed all science in its debt by the interesting and successful experiments which it has carried on in the importing and breeding of parasites and other natural enemies which prey on the gypsy moth and the brown-tail moth. This work was inaugurated on a large scale in cooperation with the U. S. Bureau of Entomology in 1905, shortly after the Commonwealth had for the second time undertaken to suppress these two insects. The work has been attended with a large measure of success, and during its prosecution various interesting scientific discoveries have been made in regard to these insects and their life history, and also in regard to the life history of their various parasites and related insects.

The importation of the Calosoma beetle (*Calosoma sycophanta*) from Europe to destroy the gypsy moth has resulted in much practical and interesting data in regard to the beetle and its habits. It is a pronounced success.

The construction and equipment of the laboratory where the work has been carried on has attracted the attention of scientists all over the world, and in the year 1907 several eminent scientists from this country, Europe, Africa and Australia visited the parasitic laboratory, which was then at Saugus, Mass. None of these men could suggest improvements in the methods used, but they all found many to admire and copy in their own countries where similar lines of investigation were being inaugurated.

Much experimenting has been carried on also with the fungous disease of the brown-tail moth and with the so-called wilt disease, or "Flacherie," which attacks and destroys the gypsy moth to a large extent.

The development of spraying machines and insecticides, makes one of the most striking and important chapters in the history of the moth suppression campaign. The necessity for an insecticide possessing superior adhesive qualities, at the same time containing sufficient poisonous properties to destroy the caterpillars, was early recognized. Spraying with common arsenical poisons such as paris green, london purple, etc., had been in use for many years, but with indifferent success. When it became evident that these insecticides were not accomplishing the work desired, an effort was made to discover a more effective poison, and much time and labor were spent in this undertaking. Some of the best chemists obtainable were employed by the State and put on this experimental work, which resulted in the production of arsenate of lead.

This work was carried on in the year 1893. Since then, the use of this material has increased by leaps and bounds, until at the present time, the manufacturers of this article are shipping it to all parts of the world. Thus to Massachusetts moth work, the agricultural world owes an everlasting debt of gratitude for her persistent and successful endeavors along this line. The results of the untiring efforts of the Massachusetts Forestry Department in developing improved spraying machines, hose couplings, nozzles and other apparatus of this nature have completely revolutionized this industry and present a record of accomplishment in this line never before equalled.

By improved machinery in spraying we now are able to spray woodlands at about $6 an acre, while formerly the expense was $40 or more. The work as well is far more thoroughly done. While this improved spraying machinery is highly appreciated in the moth-infested country of New England at present, it will take time for others to recognize its merits until the use of similar machines is demanded elsewhere. When the elm leaf beetle and similar insects and diseases begin affecting tall trees elsewhere, which is inevitable in the future, then I am confident the results of our Massachusetts inventions will be appreciated. Already the cities of Washington, Baltimore and Albany are using these high-power tree sprayers, and others are bound to follow.

By being able to throw a stream over the tallest of our shade trees from the ground and hence eliminating the cost of climbing, not only is the great expense of labor overcome but a whole street can be sprayed during the same length of time formerly required for the treatment of but a few trees. Our latest device is to substitute auto trucks for horses in our highway, shade tree, park, and city work, which is proving very satisfactory. The same power that drives the auto also does the spraying.

With our present spraying equipment of all kinds in Massachusetts alone I believe we use in a single season nearly one thousand tons of arsenate of lead. The State Forester's contract for lead the past year was five hundred tons.

One would hardly expect that such a pest as the gypsy moth would be an aid to the introduction of forestry methods in the treatment of our woodlands. Rather one would expect it to be the reverse, but such is not the case.

When the office for the Suppression of the Gypsy Moth and that of the State Forester were united in 1908, the writer strongly advocated that forest thinnings and improvement cuttings would be of great assistance in combatting the depredations of this pest. He argued that not only would the woodlands be in a better physiological condition for having the weakened and suppressed trees removed, and hence better able to stand the stripping of the caterpillars, but in

addition the operations of hand suppression and spraying could be more cheaply performed, because the superfluous trees would be taken out. Such cuttings thereafter as were made directly by the department were supervised by trained foresters and at the same time, he urged municipalities and private owners to do as much of this work as possible and to make use of his assistants.

Within the past year or two, scientific facts have come to light which vastly add to the importance of modern forestry practice as a control to the gypsy moth. Mr. Burgess, an entomologist of the U. S. Bureau of Entomology, who was doing cooperative work with the Massachusetts State Forester in studying the feeding habits of the gypsy moth in the laboratory and the field, found that this insect is by no means the omniverous feeder that it is commonly supposed to be; that, although it does eat the leaves of a large variety of trees, it actually thrives best on only a few, and if deprived of this favorite food entirely, soon succumbs to parasitic enemies.

These experiments of Mr. Burgess were supplemented by some observations of Mr. Fiske, another cooperating government entomologist, made in Europe. Mr. Fiske returned to this country last year convinced that the chief reason for the comparative harmlessness of this insect in that continent is due to the better silvicultural condition of the European forests. This silvicultural condition has been brought about by centuries of forestry practice. In addition, as already observed in Massachusetts with white pine, its freedom from the pest in clear stands proved also true of all coniferous growth abroad, especially in Germany, because the conifers are all highly resistant trees. The writer after a study of these conditions in Europe in the summer of 1912 returned with even greater conviction that forestry management can be made a great factor in moth control. Under proper conditions we, too, should have a much larger percentage of coniferous growth, but unscientific lumbering and forest fires have conspired to reduce it to a minimum.

These discoveries have moulded beautifully into the Massachusetts State Forester's methods of management, and offer a wide field for forestry development. Our woodlands

should be thinned and the favorable trees, notably the oaks and birches, removed. Where there is little chance of resistant species taking place of those cut out, artificial reforestation must be resorted to. Such operations must in time result in the removal of a large share of our scrubby oak woodlands and their replacement by fine plantations of conifers; clear stands of resistant deciduous species are also practical undertakings. So important has this subject appeared to the U. S. Bureau of Entomology that it induced the U. S. Forest Service during the past year to cooperate in experiments to test the value of forestry work in moth suppression. The Massachusetts State Forester has increased his staff by the addition of two professional foresters to the Moth Division of his department, and they are carrying on a regular campaign urging woodland owners in moth-infested sections to put their lands under proper forest management. Several gangs are now at work under direction making improvement cuttings.

If forestry work is an aid in the control of the moth, conversely the gypsy moth is of assistance in the development of forestry practice, although at first sight it would seem to be a death blow to this development. I can safely say that as a result of our moth depredations thousands of acres of our woodlands are being put under scientific management which otherwise would never have had such care for some time to come.

In conclusion, therefore, while the expenditure of vast sums of money has been necessary to combat the moth ravages in one of the most noted insect warfares ever undertaken by a single state, nevertheless, such an expenditure has been fully warranted by the results; and to Massachusetts must be attributed the courage of attempting and prosecuting a work recognized the world over as a most plausible and worthy undertaking. The many beneficial accomplishments which have been the outgrowth of this work have contributed largely to the enrichment of both science and industry, thus making Massachusetts again a world benefactor.

The International Institute of Agriculture

By A. C. True,

U. S. Department of Agriculture.

The establishment of the International Institute of Agriculture was due to the initiative of David Lubin, of Sacramento, California. He is a European who came to the United States in his youth and built up large business enterprises in California. He then felt a call to devote himself to the promotion of the general welfare of mankind and after much thought decided that he could best do this by securing the establishment of an international institution for the promotion of agriculture.

His conception was for some time generally considered impracticable of realization. Finally he made a strong direct appeal to the King of Italy, Victor Emanuel III, who was so impressed that he decided to attempt the foundation of an International Institute of Agriculture with headquarters in Italy. January 24, 1905, the King sent a letter to the president of the Council of Italian Ministers, in which he set forth the objects of the proposed institution. This was followed by an International Conference attended by delegates from 40 countries, which was held at Rome, May 28-June 7, 1905. At this conference a treaty was framed providing for the organization and maintenance of the Institute and defining its field of operations. This treaty of June 7, 1905, forms the constitution or charter of the Institute.

The King of Italy in 1906 endowed the Institute with the revenues of certain estates amounting annually to about $60,000. A noble building for the Institute was erected on the hill immediately adjoining the City of Rome on the north, in the midst of the beautiful park of the Villa Borghese (now officially known as the Villa Umberto I), the site being given by the Italian Government. This building was dedicated in 1908. Initial sessions of the Permanent Committee and the General Assembly of the Institute were held during that year, but it was not until April, 1909, that its technical and scientific work was regularly organized.

The Institute is governed by a General Assembly and a permanent executive committee.

The Assembly is composed of representatives of the adhering Governments. It receives the reports of the permanent committee and the general officers of the Institute on the work and expenditures and on the basis of these and other papers and resolutions presented to it, determines general policies, approves new lines of work, and fixes the financial budget for a biennium. Four meetings of the General Assembly have been held, the last being in May, 1913.

The Permanent Committee directly manages the Institute, puts into operation the decisions of the General Assembly and prepares the propositions which are laid before it during its meetings. This Committee is composed of one member from each of the adhering countries. Mr. Lubin represents the United States on this Committee. It meets at least once each month, except July, August, and September, and also works through four standing sub-committees and special sub-committees. The chairman of the four standing sub-committees, with the chairmen and vice-chairmen of the permanent committees form "the special committee," which considers and reports on general administrative questions, personnel, discipline, etc.

The chairman of the permanent committee is president of the Institute. There are also a vice-president and a secretary-general. The president is Marquis Cappelli, of Italy; vice-president, M. Louis-Dop, of France; secretary-general, Prof. G. Lorenzoni, of Italy.

The work of the Institute is divided among four bureaus: (1) The bureau of the secretary-general, (2) the bureau of general statistics, (3) the bureau of agricultural intelligence and plant diseases, and (4) the bureau of economic and social institutions. The bureau of the secretary-general has charge of the personnel, financial, and other routine business, the building and its equipment, the printing and distribution of publications, the library and general bibliographical work, and, as a more recent service, the preparation and publication of an annual compilation of agricultural legislation in the different countries of the world.

The bureau of general statistics collects, collates, and publishes statistics of production and commerce in agricultural products, both animal and vegetable, throughout the world.

The bureau of agricultural intelligence and plant diseases collects and publishes information regarding the progress of scientific and experimental investigations and practical experience in agriculture throughout the world, and, as a branch of this work, gives special attention to the diseases of plants and to entomology.

The bureau of economic and social institutions collects and publishes statistics and general information regarding agricultural cooperation, insurance, and credit, together with other matters relating to the economic and social organization of rural communities.

Those publications of the institute which have a bearing on the formation of the price of the staples (such as crop reports, and data on exports, imports, and stocks) are based exclusively on official information, supplied direct to the Institute by the adhering Governments.

The other publications are produced from the following sources:

(a) Information officially communicated by the Governments.

(b) Original articles contributed by eminent authorities designated by the adhering Governments.

(c) Excerpts and abstracts of articles translated from the 2,225 official and unofficial periodical publications of the world received by the Institute.

The Institute prints and publishes two annuals, and three monthly and one weekly bulletins, together with a considerable number of monographs on special subjects. The annuals are on agricultural statistics and legislation, respectively; the monthly bulletins are on (1) agricultural statistics, (2) agricultural intelligence and diseases of plants, and (3) economic and social institutions; and the weekly bulletin is bibliographical. The monthly bulletins are published in the French, German, English, Spanish, Italian, and Hungarian languages.

The bureau of the secretary-general gives much attention to building up a great library of the world's agricultural literature. The library now receives 2,225 periodicals, 669

in English, 482 in German, 377 in French, 276 in Italian. About half of these periodicals are exchanges. It also has over 25,000 books and about the same number of pamphlets. A preliminary catalogue was published in 1909; another is promised for 1914, and then annual supplements will be issued. The weekly bibliographical bulletin of the Institute contains a list of works received by the Institute, notices of articles of general interest appearing in the periodicals, and the titles of legislative acts relating to agriculture.

A universal bibliography of agriculture is planned which will comprise the material in the weekly bulletin, thousands of additions references furnished by the Institute of Bibliography of Brussels, or derived from other sources by purchase or otherwise. It will include information regarding rare works on agricultural subjects, gathered from the catalogues of other libraries, reviews, etc.

The bureau of the secretary-general has also undertaken the preparation of a Yearbook of Agricultural Legislation, which will record the progress in the domain of law of the world-wide movement for the improvement of the economic and legal conditions of agriculture and rural communities. Yearbooks for 1911 and 1912 have been issued.

The Institute is also endeavoring to promote various enterprises which are of interest to one or more countries and which can be helped through this international agency. One example of this kind of activity was seen in connection with the recent investigations of the European systems of rural credit and cooperation made by the United States and American Commissions on Rural Credit. The Institute aided these Commissions in planning their work and itinerary, collected and published much information suited to their requirements, arranged for a meeting of the Commissions at Rome at the time of the meeting of its General Assembly, and thus brought them into touch not only with the King and Government of Italy, but also with the delegates of the Assembly, among whom there were many of the eminent authorities on rural credit systems. In this way the Commissions were enabled at the outset of their European journey to get a general survey of the subject they were to study and to learn much which would enable them to make their

studies in the different countries under the most favorable conditions.

An example in a different line is found in the relation of the Institute to the International Phytopathological Conference which is to be held at the Institute beginning February 24, 1914. This is called on the invitation of the French Government to consider the scientific and governmental problems connected with the control of plant diseases and insect pests. By agreeing to call this meeting at Rome the French Government gives a substantial proof that it considers the Institute well qualified to be a center for important international gatherings relating to agriculture.

The Institute will assemble a large amount of information regarding the agricultural inspection service in different countries in advance of the meeting and will also place at its disposal the resources of the library and archives of the Institute.

The fourth session of the General Assembly of the Institute was held at Rome, May 6-12, 1913. Fifty of the countries adhering to the Institute were represented by from one to eight delegates, the total number present being 114. The absentees were Egypt, Mexico, and the Dutch East Indies. The delegates from the United States were A. C. True, David Lubin, Prof. C. W. Pugsley, of the Agricultural College of Nebraska; Spencer Ewing, of Illinois; and Prof. T. J. Brooks, of the Mississippi Agricultural College.

A meeting of all the delegates was first held at which the report of the president of the Institute on its work during the previous biennium was received, as well as reports and resolutions on behalf of the permanent committee.

To consider the matters thus brought before it, the Assembly was then divided into four committees on (1) Administration and Finance; (2) General Statistics; (3) Agricultural Intelligence and Plant Diseases; (4) Agricultural Cooperation.

These committees worked for three days and reported their conclusions to the general sessions held on May 10 and 12.

The subjects included in the discussions and reports of the Assembly were as follows:

Methods of Crop Reporting.
Commercial Statistics.
International Service of Statistics of Live Stock.
A Service of Statistics of fertilizers.
The Statistics of Agricultural Cooperation.
Crop Insurance Against Damage by Hail.
An International Service of Agricultural Meteorology.
Proposal for an International Agreement for the Control of Plant Diseases and Insect Pests.
The Production of Useful Birds.
Investigations on Dry Farming.

The report of the delegates of the United States to the General Assembly recently published as Senate Document No. 196, 63d Congress, 1st session, includes a summary statement of the recent activity of the Institute, and the business transacted by the Assembly.

The following extracts from that report may be of special interest to this Society:

"The Assembly examined and approved the account of receipts and expenditures of the Institute for 1911 and 1912, as submitted by the permanent committee, and fixed the budget for 1913 at 898,452 lire, and that for 1914 at 1,106,485 lire. This increase in the budget is necessitated not so much by the expansion in the lines of work of the Institute as from the fact that as the present lines of work become established and their usefulness is more apparent, there is a natural demand that the service rendered by the Institute shall be more elaborated and extended. To meet these requirements the Assembly voted to ask the adhering Governments to raise the unit of their contributions from 1,500 francs to 2,500 francs, as provided for in the treaty of 1905. Since the contribution of the United States is on the basis of 16 units, the amount which Congress should be asked to appropriate toward the current expenses of the Institute should be increased from 24,000 francs ($4,800) to 40,000 francs ($8,000). The desirability of this provision for the growing needs of the Institute was so apparent that the delegates of all the adhering countries voted for the increase in the budget and undertook to recommend their Governments to enlarge their contributions.

"This was one of the many evidences that the countries

which are supporting the Institute are now firmly convinced that the work which it is doing is important and valuable. There being no longer any question on these fundamental points, the Governments are more and more interesting themselves in plans for strengthening the Institute and developing its activities along the most useful lines. They are also making arrangements on a more permanent basis for doing their part in the management and support of the Institute, and for securing from it the greatest advantages which it offers. The delegates from the United States are unanimous in the opinion that the affairs of the Institute deserve most careful consideration by our Government, and that every reasonable effort should be made to so organize and develop our relations with the Institute that we may contribute in the most effective way to its proper maintenance and that our people may benefit in the highest degree from its activities.

"One of the most important, and at the same time the most difficult, tasks which the Institute has undertaken is the selection and summarizing of important articles appearing in current scientific and practical journals and the publication of these summaries in the monthly Bulletin of Agricultural Intelligence. Such work can only be done most effectively by persons thoroughly trained in the different lines of agricultural science and practice and who have at the same time a high degree of editorial insight and the capacity of succinct, accurate, and interesting expression. The services of such persons can not be secured and retained in sufcient number to cover the broad field of agriculture except by the expenditure of considerable money. The Institute has keenly felt its limitations in this regard and fully realizes that it has only made a beginning of an important service in this directon. The usefulness of what it has done is, however, generally recognized and it is hoped that in the near future the means will be provided for the further strengthening of this work. Efforts are now being made to secure a wider collaboration of experts in the different countries, and thus to bring the Institute into closer touch with those who are most intimately acquainted with the progress of agricultural science and practice throughout

the world. Closely connected with this service is the important function of answering inquiries on scientific and practical questions addressed to the Institute through the Governments of the adhering countries. With the more complete organization of the bureau of agricultural intelligence the importance of the Institute as an international clearing house for agricultural information will doubtless be greatly increased."

The officers of the Institute have a high appreciation of the scientific work relating to agriculture which is being done in the United States. They desire to be brought into closer touch with this work, and with the men who are engaged in it. They will, therefore, greatly appreciate any aid which the members of this association may be able to give the Institute, and will endeavor to satisfy, as far as they can, any requests for information which may be made either through correspondence or personal visits.

The Institute will be glad to get for its library copies of any papers which members of this association may publish, and which are not included in journals and books.

Agricultural Education in Latin America

By Clinton D. Smith

Former Director of the Agricultural School at Piracicaba, Brazil.

I am sure that the genial secretary of this Society, when he allowed me to address you today, did not expect me to do much more than to put into simple, untechnical language the results of my observations in lands to the south of the Panama Canal on the continent which Ex-President Roosevelt is amply justified in calling the forum of the world movement of the next century on this continent. He expected simply and solely such a report as a travelling soldier might give to his comrades after an absence of five years and more, years occupied in observing conditions and organizing an agricultural college under conditions as opposite to those existing in his mother country as the human imagination could well picture.

We are to look at methods, equipments, faculties, colleges and stations in countries where the universal language is latin. Now this difference of language is a matter much more important than you have been accustomed to think. It indicates much more than a different way of expressing the same idea, the same thought. It means a different idea and a different thought, a thought made up of the same components but put together in a different way. The Brazilian boy, whose mind, from easily understood historical reasons, seems all memory, and whose ambition seems much awry, needs a training fundamentally diverse from that required by the average student at Cornell or Iowa, as his body seems to thrive on food here considered quite out of harmony with the supposed laws laid down in bulletin and report. These things are self-evident and I waste your time in laying emphasis upon them, except as a basis for my petition that you disabuse your minds of preconceived ideas of pedagogic forms applicable solely to teutonic minds, while accompanying me this afternoon on our necessarily long journey across the equator and to the sunny lands of South America.

THE BRAZILIAN IDEA.

Having spent more than five years in Brazil, I beg permission to dwell much more at length upon conditions in that country than in either Argentina, or Uruguay, both of which I visited, or Peru or Chili, the schools of which I was obliged to study at a distance but in an atmosphere entirely in sympathy with their institutions.

Brazil is, nominally at least, a Republic similar to ours in having a national constitution copied after ours, giving to the central government limited powers therein delegated and reserving to each of the twenty-one constituent states all powers not thus delegated. In its national system of education, the domain of the agricultural college and station, together with all matters appertaining to the teaching of the farmers direct, was left to the department of agriculture.

Brazil embraces within her boundaries more territory than the United States, less Alaska, but this territory is distributed, not in the temperate zone alone, but extends from the equator to the snowclad hills of Rio Grande de Sul. The task, therefore, of developing any system of education or any type of institution adapted to all of the states has been for the present abandoned. Certain states are ready for agricultural schools, experiment stations and even the college, while others are far from that happy period. In general the states nearest the equator are the most backward.

Before discussing the institutions related to agriculture it is well to remember that the twenty odd millions of the population of Brazil is far less homogeneous than is that of this country. It is not a pure white race that we are to meet, but a nation composed of people of mixed blood. The students who come to the schools in Piracicaba, in São Paulo, one of the southern states, farthest from the equator, were white, or chocolate or dark olive or black, indicating all possible grades of mixture of Indian and negro blood. Members of the faculty used often to boast that they traced directly to Indian blood but two generations back. You are aware that while the negro problem is one of the most difficult that this nation has to solve, the Brazilians hope they have avoided the problem altogether by attempting amalgamation, with all its attendant horrors, yet I found racial

antipathy as rife there as here, though manifesting itself in a different way.

The raw material furnished the agricultural schools is good. The young men are not such as we have, but they are intelligent, not lazy, alert and ambitious, eager to learn the practical usable things, docile, easily disciplined and agreeable to deal with. They come to the college illy prepared, but it is not the fault of the boys nor of the system and program of the common schools, but of the methods and teachers in those schools. One of the chief obstacles in the way of all higher education in Brazil is the lack of obedience to the simplest pedagogical rules in the elementary schools and the consequent weakness of the candidates offered to the colleges.

The agricultural resources of the nation are great, but the principal crops are such as to invite the system of large holdings of land and consequent lack of community life and spirit. Coffee is almost entirely confined to large fazendas of from 300,000 to a million trees. This means that the distance between farm homes is great and means of communication very primitive and imperfect. Of roads well cared for, there are few. In most cases, in driving from one fazenda to another, you pass through fields, coffee orchards, by long rows of cabins of the laborers, across unbridged streams and arrive, unexpectedly, and unannounced save by the barking of hunting dogs, at the beautiful mansion of the gentleman owner. The number of farm owners is therefore relatively small, and their children constitute but a small proportion of the total school population. Again these fazenda owners do not remain on their properties during the year. For the most part they migrate to São Paulo or other large city, and their children attend the city schools, a fact which turns their attention from rural life and draws them toward the professions or business. Brazil is suffering, as are all other nations, with the disease of which one of the chief symptoms is the movement of the population cityward.

In São Paulo, I could find no middle class between the rich and the poor except, perhaps, the merchants in the cities, and these were, for the most part, immigrants or sons

of immigrants. The farm owner is wealthy, his laborers poor, ignorant and almost hopeless. From this latter class the agricultural schools will draw but few of their pupils for many years to come. It is, then, from the families of the fazendeiros and of the merchant that the new institutions are to receive their students, many of whom have had at least part of their preparation in the best schools of Europe.

I have spoken thus far of conditions not alone in the the coffee district but of the states to the north of São Paulo. In Paraná, Santa Catharina and Rio Grande do Sul, a somewhat different state of affairs exists. In the last-named state, the Germans are crowding in and are establishing relatively small holdings, growing the cereals and exporting live stock. The new school at Porto Allegre has, therefore, a much different clientele, much more like ours, and may adopt methods found so successful in this country. While many of the other states of the republic are not yet ready for agricultural colleges and will not be until the elementary schools have been developed, the federal government is not idle but through inspectors and ambulant instruction is doing something to educate the people.

In Brazil, as in these United States, agriculture was slow in being recognized by the creation of a separate bureau in the cabinet of the President. It was in 1909 that the first Secretary of Agriculture entered upon his duties. Early in his career he began the study of the question of agricultural education, and a man recently from the United States of the north was asked to present a suitable scheme. This proposition included, among other details, the general idea of a central agricultural college, a graduate school at the capital, manned and equipped to carry on investigations of a technical kind and to offer courses, very advanced, in all divisions of agriculture and the sciences upon which they are based. Such a school has been organized, equipped and put under way, opening its doors in August of this year. The course of study at this National Agricultural and Veterinary College is thus outlined in the decree of Oct. 20, 1910.

Article 5. The "Escola Superior" of Agriculture and veterinary medicine shall offer two distinct courses, that of "engenheiros-agronomos" (corresponding to our agricul-

tural course pure and simple) and that of Veterinary medicine, being each divided into preparatory and special.

Art. 6. The instruction in the course of agriculture is intended to promote the scientific development of agriculture by the technical preparation of professional men competent to give instruction in the highest agricultural classes, ready for the technical offices in the ministry of agriculture and for the management of such enterprises as relate to the rational control of either large properties or industries.

Art. 7. The course for veterinarians is designed to constitute in the nation a body of professionals for the practice of veterinary medicine and surgery, for teaching these subjects and for the official positions related to this subject.

Article 8 gives the outline of the preparatory course in agriculture as follows:

The preparatory course is to be of one year and to include experimental physics, metereology and climatology, principally of Brazil, inorganic chemistry with chemical analysis, botany, morphology, vegetable physiology, general and systematic zoology; general, analytic and mechanical geometry, designing (probably free-hand drawing). According to the plan proposed, the graduates of state colleges should complete their scholastic training here.

Finally we have the outline of the special course, so-called as given in the decree. First year:—organic and biological chemistry, systematic botany and phytopathology, animals useful to crops and hostile thereto, agricultural entomology, agricultural mineralogy and geology, agricultural chemistry, topography, road-making, designing, drafting.

Second year:—Vegetable chemistry and nutrition, agricultural mechanics, general agriculture, industrial crops, silviculture, agricultural microbiology, conservation of agricultural products, machine design and drafting.

Third and last year:—Special agriculture relating to horticulture, fruit culture, grape culture and bush fruits generally, general and special zootechny, hydraulics, materials of construction, farm buildings, rural economy and legislation, agricultural organization, farm bookkeeping, veterinary medicine, hygiene, designing of projects in hydraulics and rural constructions.

After this course of three years is to follow one of a year in which the young men who have completed the work may specialize.

The equipment of the school is good, the situation most admirable. The campus is quite within the city limits of the capital. A large farm at no great distance is maintained for practical work in soils and crops. The buildings are on a broad and generous plan, as they may well be where there is no question of heating plants, either central or otherwise. The offices and main corridors are tastefully decorated and in all details there is the customary obeisance to aesthetic. The chemical laboratories leave nothing to be desired either as to hygiene or equipment. I did not visit the veterinary department.

The faculty consists of the full professors of the various sciences with no inconsiderable list of assistants. Listen to one article of the decree etablishing the institution: "Art. 33. The professors and assistants shall be appointed for life, from the date of taking their posts and shall not lose their positions and emoluments unless under the penalty of law and the regulation of the school."

You will understand by this that practically in all the public schools of that great nation, there is no insecurity of position, once nominated. Once a professor of mathematics in a public school, always a professor of mathematics, and no one can put you out or move you without your request unless you commit crime of some sort. The head of the school can have no control over the make-up of his faculty. The honored head of this Brazilian college told me that the faculty was appointed without consultation with him in many cases, and not infrequently for reasons a long way from competency, ability and experience. In one case a man arrived at his office, so the story goes, and quietly informed the director that he was the professor of phytopathology. In the course of the subsequent conversation, he very naively asked what the meaning of the term phytopathology was or might be. I remember once in my own case a man applied for a certain professorship and came to see me about it. He also did not know what the word describing the subject meant but assured me

that whatever the material he would study to keep ahead of the class. I am well prepared to believe, therefore, that in this national school which opened its doors after I left the country and concerning which I know so little, the professors were selected rather because related to certain prominent men than because of competence. How many of them were so selected I do not know.

Imagine, if you can, the possibilities of a school where every detail of the management is controlled by a decree of the government, if not by a law of the legislature, and where the faculty is thus selected and maintained. Unfortunately for Brazil, hosts of other projects have been presented, been approved by the government and put into enthusiastic operation only to meet sudden death by freezing as soon as the first enthusiasm has cooled. It is hard to learn that programs, courses, regulations amount to little by themselves. The motive power is the man, the other factors simply give opportunity and indicate the direction of the movement.

Naturally the National College can be of no advantage to Brazil without the attendance of many students. These students must be prepared in the elementary branches to utilize the instruction offered. Without a radical improvement in the condition of the common schools of the smaller cities, villages and rural communities, it will be difficult to find a student body well prepared. I have mentioned these details to suggest some of the obstacles in the way of the growth of the school. So great is the need of such an institution, however, and so opportune is the time for its beginning that I cannot but have great hopes for its future.

It must be said, too, that this establishment is but one factor in a general plan of wide scope. The decree founding it specifically mentions ten other phases of the activity of the department, among which are three medium grade schools of agriculture at Pinheiro, Bahia and Porto Alegre, demonstration farms, eight boarding schools for boys, giving primary instruction in agriculture, domestic science schools, ambulant courses, short courses, technical advice on consultation, and meetings of farmers corresponding to our farmers institutes.

Carrying out the plan to some extent, there have been es-

tablished at various points experiment stations and demonstration farms, and also breeding establishments and holding stations for imported animals. This work would proceed faster were it possible to secure competent men to head the stations once established.

State Schools.—São Paulo is the most progressive state in the Brazilian confederation, and might well have been expected to be one of the first to found an agricultural school since her main dependence is coffee, a purely agricultural product. Many years ago one of her weathy and patriotic citizens, Dr. Luiz Vicente de Souza Queiroz, thought to establish on his fazenda, San João de Montanha, contiguous to the city of Piracicaba, a practical school of agriculture, but did not appreciate the cost of originating, equipping and maintaining such an establishment. An international strife was beginning and financial matters were in sore straits. The time was not ripe nor were the resources of the senhor Queiroz sufficient to take the first step in such an important undertaking.

In 1892, therefore, he donated the fazenda to the state government, that his wishes might be fulfilled and an agricultural college be established thereon. The gift was accepted. After long delays due to changes in the personnel of the department at the capital and to other causes, the fazenda was properly arranged and suitable buildings erected, which were inaugurated on the fourteenth of May, 1907, Dr. Carlos J. Botelho being the Secretary of Agriculture, who had pushed through the erection of the buildings and the other preliminary work. The buildings were occupied for the first time during the closing trimester of 1907.

At the beginning of the school year of 1908, the author was appointed directer, assuming his post in May of that year. A state school had been maintained in Piracicaba since 1901, the first class graduating in 1903, seven members. Director succeeded director as secretary succeeded secretary, the number of students gradually increasing, the course becoming more and more extended and the faculty strengthened by the importation of foreigners.

In 1908, when the school was reorganized according to the wish of Dr. Botelho, American methods were introduced.

Naturally the fundamental changes had to be brought in gradually, since the former faculty was in large measure retained. The growth in number of students was encouraging: viz, from 40 in 1908 to 176 in 1912, with 200 applicants not admitted because not sufficiently prepared.

The entrance examinations were made to include arithmetic complete, something of algebra and geometry, Portuguese grammar and ability to write correct Portuguese, geography, practical work on the farm and in carpentry. It was soon found that the average candidates were not well prepared and a preliminary course, first of one year, and later of two years, was established. Into this course was crowded not alone the arithmetic but also the algebra and geometry, two years of French, and work in carpentry and on the farm, besides the materials first mentioned. The students in this preliminary course were required to live in the dormitories.

The dormitory life gave an excellent opportunity to study the Brazilian boy at close range. I found him to be exceptionally impressionable, quickly responding to good influences, good raw material partially spoiled in the schools but quick to understand and appreciate correct living and correct teaching. It was noted that the more severe the examinations, if they were just and honest, the more the students were attracted. What they feared and hated were partiality, favoritism, injustice. What they needed more than intellectual instruction was inspiration, and this could be given solely through personal contact.

The faculty was about evenly divided, half Brazilian, half foreign. There was no entity known as the faculty with legislative power. The director was held responsible for the entire administration at the school to the Secretary of Agriculture. The director was never, therefore, between two fires, a state board and a faculty. He had but one chief, a fact which simplified matters greatly. In this school, too, for the five years of the incumbency of a North American, there were no nominations made to faculty or to administrative offices except by the director.

As in the case of the National School at Rio Janeiro, the object and aim was to prepare scientists to teach in the rapidly growing number of agricultural establishments in

the country, and to prepare young men to take charge of farms and of industrial propositions. The course of study was planned with this aim in mind. Very naturally it was submitted as enacted into law, by the director of the school after consultation with the members of the faculty. It was a compromise, there being no use in going faster in the upward march of the teaching methods than the faculty could follow and support. This faculty coming from the four corners of the earth required much persuasion, much argumentation and much force applied to put the course into successful execution, and even then with results which left much to be desired.

Here, then, is the outline of the couse of three years leading to the degree of "Agronomo," the figures designating hours per week:

FIRST YEAR.

First semester.	*Class. room.*	*Laby.*	*Second semester.*	*Class. room.*	*Laby.*
Algebra	3 hrs.	......	Geometry, trigonometry	3 hrs.	.....
Geometry	3 hrs.	.....	Physics, mechanics	3 hrs.	.....
Physics	......	4 hrs.	Chemistry, general	3 hrs.	......
Chemistry, general	3 hrs.	......	Botany, systematic	3 hrs.	2 hrs.
Botany	3 hrs.	4 hrs.	Zootechny, general, judging	3 hrs.	......
Zoology	4 hrs.	......	Drawing	......	4 hrs.
Zootechny	2 hrs.	......	Farm operations	......	4 hrs.
Drawing	......	4 hrs.	Carpenter work	......	4 hrs.
Total	18 hrs.	12 hrs.		15 hrs.	14 hrs.

SECOND YEAR.

First semester.	*Class. room.*	*Laby.*	*Second semester.*	*Class room.*	*Laby.*
Surveying	3 hrs.	4 hrs.	Heat, light, acoustics	3 hrs.	2 hrs.
Botany, microbiology, bacteriology	2 hrs.	4 hrs.	Chemistry, soils and industrial	......	6 hrs.
Chemistry, qualitative analysis	......	4 hrs.	Phytopathology and entomology	2 hrs.	2 hrs.
Agriculture, geology and soil physics	3 hrs.	2 hrs.	Surveying	2 hrs.	4 hrs.
Electricity and Climatology	2 hrs.	......	Agriculture, soils and crops	3 hrs.	2 hrs.
Zootechny, races, breeding	3 hrs.	2 hrs.	Zootechny, horses and cattle, care and feeding	2 hrs.	2 hrs.
Total	13 hrs.	16 hrs.		12 hrs.	18 hrs.

THIRD YEAR.

First semester.	Class room.	Laby.	Second semester.	Class room.	Laby.
Horticulture	2 hrs.	2 hrs.	Chem. analysis and technology	2 hrs.	6 hrs.
Economics	2 hrs.	......	Zootechny, veterinary medicine	2 hrs.	2 hrs.
Agriculture, crops, machines	4 hrs.	4 hrs.	Entomology	......	1 hr.
Zootechny, stock feeding, poultry	2 hrs.	1 hr.	Horticulture and apiculture	1 hr.	4 hrs.
Agr. chemistry and technology	2 hrs.	6 hrs.	Agriculture, coffee, forestry	3 hrs.	2 hrs.
Rural engineering, steam and gasoline engines, windmills, water-wheels	2 hrs.	2 hrs.	Drainage, irrigation, construction	3 hrs.	......
			Dairy work	......	2 hrs.
Total	14 hrs.	15 hrs.		11 hrs.	17 hrs.

The classroom instruction was given generally by lectures, using a text-book for reference. These text-books were mostly in French, the Portuguese language containing few scientific works. In chemistry and botany there was much laboratory work. So, too, in agriculture there was much field work. In the preliminary course the students spent the hours from 7 to 9 daily either in the carpenter schop or in the field. There was no dislike shown to this work with the hands. Every one of the boys was ambitious to learn how to plow, cultivate, manage a mowing machine, drive teams. He was anxious to return home competent to teach the laborers on his father's fazenda how to handle tools and how to do properly all kinds of manual labor. Some of them became expert in carpenter work and in butter-making, and there were few absences in any line of this so-called practical work. So, too, in the laboratories of chemistry, botany and zootecheny, the attention and attendance were excellent. This was the more surprising because this form of instruction is rare in the country, and again these boys born in tropical countries and where slavery existed 20 years ago, are supposed to have an inherent aversion to manual labor.

It was difficult to overturn the fixed habits of teaching mathematics, namely, by lectures without the solution of problems by the boys. This was done, however, by the persistence of Professor Sanders and, to the surprise of everybody interested, the boys took kindly to the new way, went at the working of examples with enthusiasm and soon

had no use for simple memorizing of illy understood rules.

The equipment of the school is good. The main building, some 300 feet long by 60 wide, situated in the center of a magnificent tropical park with its 163 varieties of palms, 80 varieties of roses, innumerable euphorbias beside the poinsettias, whole lists of *Leguminosae,* besides the giant schizolobiums, with gravelled roads swept each Saturday and always in perfect order for the hosts of automobiles and carriages which frequented them on the Sabbath, and with outlying buildings for carpentry, chemical laboratories, gymnasium and swimming pools so popular in that climate. The farm of something like 600 acres had its coffee orchard, cane field, cotton field, rice field, sweet potatoes, mandioca, alfalfa, irrigated garden, forest demonstration area, fruit orchard and live stock pavilions with Simmenthal, Holstein and native cows and a hundred head of excellent specimens of swine.

It is too early yet to report striking results. The school is young, yet, its graduates are occupying strategic points in the heroic struggle which the nation is making against ignorance and consequent losses. Already the important offices in experiment stations, national schools, breeding establishments, demonstration farms and in the state and national departments themselves are satisfactorily filled by men educated in this school. Few of the graduates have returned directly to the farms, yet these are making good. In some cases like that of Francisco Iglesias, the graduates are making important discoveries in fields where they have few competitors. I am filled with hope for the future of the establishment and, while mistakes must be made and its growth slow, yet in time it will do royal service for the state and nation.

Other states have established schools of agriculture. Minas Geraes, long ago initiated and maintained certain schools of the second grade, but they have not grown nor influenced materially the methods of the state. Nor have there been conspicuous results from similar schools anywhere in Brazil. At Lavras, joining hands with American missionaries, they have built up a serious institution doing good work, especially along lines of stock and field crops.

In the matter of experiment stations, to São Paulo belongs the honor of having the best and far away the one of most influence. This station is located at Campinas. It is twenty-six years old, and has carried forward several series of experiments with sugar cane and with coffee, giving results very helpful to the farmers. It is well equipped with chemical, bacteriological and entomological laboratories, has good collections and a splendid farm. It is under the administration of a Frenchman, a graduate of the University of Paris, and a competent man.

The National Government has recently begun experimental work in rubber production, and has established a station in Pará to deal solely with problems relative to that subject. There is much need of systematic work in devising a national system of experiment stations.

REPUBLIC OF URUGUAY.

Here we have to deal with the smallest of the South American countries, an area of 72,000 square miles as against 1,135,000 for Argentina and 3,300,000 for Brazil. It is also the most thickly settled country of this southern continent, having 6.2 persons to the square kilometer, while Brazil has but 1.7 persons and Argentina but 1.8, Chili 3, and Peru 2.6.

Uruguay has still another pre-eminence. It has little or no waste land, no craggy mountains or even lofty hills with bare sides without grass for cattle and fertile soil for the husbandman. While in past years, the growing of cattle and sheep upon the gently undulating countries of the western provinces may have been the principal industry, at present the cereals, wheat and corn, are the main productions of the fields, with splendid vineyards and fruit orchards to occupy the attention and satisfy the ambition of the fortunate ruralist interested in horticulture. The total number of animals in Uruguay has increased from twenty-six million in 1900 to thirty-five million in 1908, with every possibility of still farther increment should the present high prices of meat continue.

The grasses of Uruguay are perhaps the finest in South America. Alfalfa may possibly be better adapted to Argentina, though this is doubtful, but pasture grasses find

their best development in this little Uruguay. There are also twenty-six million sheep on the continuously dry hills of the inner provinces, an increase of nearly eight millions in the past eight years. Uruguay can be depended upon to do her full share in supplying the markets of the world with beef and mutton.

The medium temperature is not far from 65 degrees F., with never snow and seldom even frost. The ground can therefore be plowed and cultivated at any time of year, and there is less need of storing forage for winter or the dry season. All of these conditions make for the growth of the live stock industry, yet the extreme fertility of the soil combined with the fact that there are no mountains nor deserts bid for the extension of field agriculture and the production of the cereals. In Montevideo and elsewhere there are established experiment stations and annexd laboratories for investigation and incidentally instruction. Each of these stations has under its supervision a large farm for demonstration purposes. Some idea of the size and equipment of these stations may be derived from the fact that the last four established cost the neat sum of eight hundred thousand dollars, something over four million francs.

Besides these experiment stations and independent of them there is a series of demonstration and model farms and stock breeding establishments, each one devoted to the specialty in evidence in the section when located, there being a so-called model farm attached to the central agricultural college at Montevideo. There is also a national nursery for fruit and forest trees at Toledo. Note in this connection that there is a branch of the department of agriculture devoting itself exclusively to the fight against insect and fungus diseases of plants, and still another devoted to the diseases of animals. In all of this scientific and technical work, the nation has not been afraid to invite foreign scholars and experts to do the organizing and even the continuation of the work.

Counting the value of the Uruguayan peso as equal to that of a dollar, it is notable that this nation spent last year over three million dollars in its educational system. Naturally no small proportion of this sum was spent in Montevideo, a

city of 450,000 inhabitants and the national capital. Still the agricultural college received $128,925, and veterinary college, $81,000. Primary education received $1,900,000. Of this sum the major part was used in building up the rural schools, which are now scattered broadcast over the country, affording opportunity for all children of the farmers to receive instruction in reading, writing, arithmetic, geography, ethics and elements of agricultural science.

It was not until 1906 that agricultural education was definitely organized in Uruguay. The plan, now in full tide of successful operation, involves an agricultural college at the capital, with a school of veterinary attached, four experiment stations, with schools attached, located in the provinces of Salto, Paysandú Cerro Largo and Durazno.

Unfortunately while the government is republican in form, with a President, legislature and judiciary, the country is one of frequent revolutions to which the citizens seem to pay little or no attention. The cabinet of the President contains a minister of agriculture, and the matter of agricultural education has received attention. The country is divided into zones, in each of which is stationed a competent technical instructor and inspector, well trained in the schools of his own country and in those of Europe and the United States, a man who has traveled widely and at the same time is thoroughly familiar with all the details of farm management at home. It is his office to instruct the farmers in general principles and in their application to his local and immediate problems.

There is a school at Toledo of "Capatazes" and six experimental and demonstration farms under the control of the division of agricultural protection. Note that the experiment station and demonstration farms, scattered over the nation also teach agricultural practice to young men who attend regular classes.

At the Agricultural College at Montevidéo we find an imposing, rectangular building of three stories, located in a new but even now beautiful park, almost if not quite within the city limits and with good street car connection with the heart of the city. There are no boarding students. The building, therefore, is given up to fully equipped chemical

laboratories, organic, inorganic, qualitative, quantitative and technical; I found the boys analyzing not alone soils and fertilizers but organic products as well; an unusually well-furnished botanical laboratory in immediate touch with an arboretum and botanic garden; a fully equipped dairy laboratory with apparatus for manufacture, for analysis and for detection of adulteration; a laboratory for agricultural industries; a museum and a library; and classrooms, offices and collections of materials specially interesting to special departments.

The requirements for admission are:—age limit, seventeen or above; approval in examinations in mathematics, Spanish, French, English or German, geography, bookkeeping, physics, chemistry, cosmography, natural history, American history, literature, philosophy, civic instruction, drawing, and gymnastics. Surely a formidable array.

Once entered in the school, the student may elect between two principal courses, practical and scientific, the one intended to prepare men to manage farms and large industrial undertakings, and the other to prepare scientists for teaching and for original investigations. During the first two years of the course, the materials are identical.

The faculty is composed of fifteen full professors and assistants, somewhat evenly divided between Orientals and Europeans. The first director or, as we would say, President, was a German, Dr. Backhaus, who gave the institution a decidedly German orientation.

The first students having been received as late as in 1907, when there entered 27. It is too early as yet to say anything as to results farther than this, that the demand for young men well acquainted with existing conditions in the rural districts and at the same time well grounded in the sciences is so keen that the young graduates are required to accept places for which they have not had sufficient general experience fitly to prepare them. Other countries have suffered from the same disease.

In the year 1911 a group of six graduates of this college was selected by the government and sent to England, France, Denmark, Switzerland, Belgium, the United States and Australia, to study agricultural conditions and methods and

institutions of education. One volume of their report has been published, and I await with intense interest the appearance of the other that we may know how these northern matters appear in the eyes of competent southerners.

It may be interesting to note that this small republic was the first on that continent to arrange in a manner at all satisfactory the question of rural banks, rural loans and rural credits generally. The government has not followed in the tracks of Belgium, which gave to its financial ditches the wrong grade so that the system designed to invigorate the country with a strong stream of necessary money should result in exactly the opposite, the withdrawing of needed capital from country districts to build up the neat, architecturally beautiful and financially remunerative brick blocks of Brussels. But this is aside.

REPUBLIC OF ARGENTINA.

This country has been aptly called the United States of the Southern Hemisphere. In its productions as well as in the temperament of its inhabitants it has a somewhat striking resemblance to its northern sister.

The Rio de la Plata, receiving the waters of the two gigantic rivers, the Uruguay and the larger Paraná which between them drain fully a fourth part of the total area of South America, spreads out into a broad and shallow estuary 200 miles long by 30 miles broad opposite Buenos Aires, and fully twice that width in front of Montevidéo.

The city of Buenos Aires, the capital of Argentina, lies but thirty feet above the high-water mark of the river, and is very flat indeed as is the country to the south and west of it. In fact, nearly the whole of Argentina is a vast level prairie, uninterrupted by tranverse streams. In the northern part, east of northern Chili, there is an elevated plateau like that of central São Paulo, equally as elevated (2,000 feet) but more broken and rugged. All of southern Argentina except along the Andes, to the west, is prairie.

Very naturally the climate varies with the latitude from the cold of Patagonia to the tropics of Jujuy or Salta. There is, therefore, a possibility of a wide diversity of products. To date the principal crops are wheat, corn, lin-

seed (flax) and alfalfa. Fruit is grown at Mendoza and at other points along the bases of the Andes, but the apples on the markets of Buenos Aires came from California or the splendid valley in Chili now so largely devoted to orchards, thanks to the energy and foresight of certain Americans from the north.

There are two perils that continually threaten the farmer on the vast plains of central Argentina, drouth and grasshoppers. As a matter of fact, however, the farmers are becoming rich by the rise in value of real estate and by the still greater advance in the price of their products. The alfalfa is the foundation of the meat exportation, which is in turn one of the principal sources of wealth.

The population is of old Spanish stock, as in Uruguay, with the same infusion of modern Spanish and Italian immigrants. The society is divided horizontally by a gulf, not a cleavage plane. In the country districts there are but two classes, the wealthy land owner on the one side and the recent or quasi recent immigrant or native laborer, on the other.

Under such conditions, the common schools cannot be expected to have attained a very influential position. Conditions here are unlike those in Uruguay in this respect.

Under such conditions, agricultural education necessarily must have had a slow and irregular growth. Various attempts were made to establish technical schools earlier, but the first permanent and really useful school of agriculture was established in 1883 in Santa Catharina, which graduated its first class, ten young men, in 1888. The next year, the school was moved to La Plata and much later, in 1906 was incorporated into and became a part of the national university, under the administration of the Department of Public Instruction. All of the other agricultural education is in the hands of the minister of agriculture.

Within the ministry of agriculture is a division called Dirección General de Enseñanza Agricola, which has charge of the practical, special and technical instruction in schools and the extension work.

Experiment stations are connected with each of the regional schools scattered over the territory, the law stating

that the two phases of government activity should never be separated. Each school has also a large farm for demonstrations.

There are eight practical schools, each adapted to the zone in which it is located. These schools are:

Specialty.	*Locality.*	*Province.*
Dairy	Bell-ville	Cordoba.
General agriculture	Bella Vista	Corrientes.
Fruitculture	San Juan	San Juan.
Subtropical	Posadas	Corrientes.
Forestry, industrial crops	Colonia Benitez	El Chaco.
General agriculture	Las Delicias	Entre Rios.
General agriculture	Puerta de Diaz	Salta.
Mechanics of agriculture	Bahia Blanca	Buenos Ayres.
Practical agriculture	Casilda	Santa Fe.

These schools are well scattered, and each serves a characteristic area. The courses include three years of study, the tuition, food, lodging, washing and clothes being gratuitous and each student receiving, besides, a daily payment of fifty cents, seventy-five cents or a dollar, according to the year of his course, which sum may be reduced for bad conduct or laziness or deficiency in scholarship.

Students enter in September or December and must be fifteen years of age, healthy and able to read, write and perform with facility the four operations of arithmetic. The course varies with the region served. At Casilda, where there is a farm of 500 acres, the three years' course includes lectures on general agriculture, special agriculture, practical work (which means daily work with teams on the farm), stock feeding, breeding, judging and management, including buying and selling, machinery manipulations and using, fruit culture, including spraying against diseases, with diagnosis of each, rural construction, general farm administration and bookkeeping, with plenty of practical work wherever possible.

At Bell-ville, Cordoba, is a dairy school where the boys are taught not alone the breeding, selection and feeding of the cows and the care of milk and manufacture of cheese and butter, but also the growing of the forage plants and grains for the concentrates, besides fruit orchards and gardens, work here also being by the boys themselves.

have for their object the preparation of farm managers, teachers, etc., in the various branches of agriculture. The school at Tucuman is devoted to tree culture, both forestry and fruit, the one at Mendoza in the foothills to grape and wine production, and the one at Cordoba to live stock. For these schools the candidates must be seventeen years old, healthy and with certificate showing that they have passed the fifth grade in the common schools. Many students are attending these schools, 90 for instance at the special grape and wine school.

Besides these schools, the department provides other means of reaching the farmers, entrusting the work to the hands of the schools of the various regions. Among these activities may be mentioned temporary courses comparable to our extension schools; ambulant schools, or rather traveling professors who visit farms on invitation, cooperative experiments, written answers to questions, and gratuities to associations or even syndicates which aim at aiding the rural development. There is a special enlargement and adaptation of the railway institute train, with its one coach for an instructive collection of material and the other for a classroom, which these southern brethren of ours have found exceedingly helpful in certain of their provinces. So, too, there are special schools lasting a week or even less, with lectures and laboratory work systematically arranged for students in the public schools and other similar ones for adults, which seem to have given good results. The apparatus necessary is taken with the teachers who do not leave the zone in which they are stationed. Furthermore, the soldiers stationed in a given region are taught the agriculture peculiar to that region, thus occupying to good advantage much time that otherwise would be wasted.

Notwithstanding the scattered condition of the rural population, the heads of certain regional colleges have succeeded in organizing societies and associations for purposes of buying and selling as well as for instruction purposes. The publications of the general department of agriculture and of the several regional and technical schools and the experi-

ment stations annexed are very numerous and exceedingly helpful to the rural population.

At the University of La Plata, the agricultural college, under the administration of the Department of Public Instruction, is housed in a magnificent building for the museums, library, classrooms and laboratories and a group of excellent dormitories. At no place other than in Berlin, did we find a museum so well arranged for use and instruction as at this university. The professors were evidently enthusiasts and were competent to transfer this enthusiasm to their students.

PERU.

There was founded in 1901 at Lima the National School of Agriculture and Veterinary, located on a delightful site and equipped to constitute a center of agricultural instruction for the nation, and to teach in its classrooms and laboratories all subjects necessary for an agricultural engineer.

The management of the institution is peculiar, complex and unfortunate, there being a council of instruction with the Minister of Agriculture at the head, which determines the make-up alike of faculty and of programs, and a council of discipline, composed of directors and faculty, which executes the same.

In 1906 there were 94 students, 48 of whom were non-paying. A preparatory course was found necessary in which are crowded all the mathematics, including trigonometry, with elementary studies in the sciences. The regular course is of three years, not differing widely from the one adopted in Piracicaba. A demonstration farm and experiment station are annexed.

From 10 to 18 men graduate each year. This school has been directed by Belgians from its foundation and has an orientation similar to that of Gembloux.

CHILI.

Chili has a school of agriculture founded in 1856 and reorganized in 1873 and again in 1907, now the central school at Santiago. To boys 17 years old or over with common

school education, a four-year course, embracing agricultural rural economy, horticulture, botany, vegetable pathology, zootechny, veterinary, general and analytical chemistry, mechanics and rural legislation. This school is designed to build up in the country a body of scientists, while eight special and regional schools aim to prepare men to be farmers.

LIST OF OFFICERS AND MEMBERS

Of the

Society for the Promotion of Agricultural Science

1914

OFFICERS FOR THE SOCIETY FOR 1914.

President—H. J Waters, *Manhattan, Kansas.*
Secretary-Treasurer—E. W. Allen, Department of Agriculture, *Washington, D. C.*
Custodian—W. J. Beal, *Amherst, Mass.*
Assistant Custodian—W. D. Hurd, *Amherst, Mass.*

Executive Committee
- H. P. Armsby, *State College, Pennsylvania.*
- W. H. Jordan, *Geneva, New York.*
- H. L. Russell, *Madison, Wisconsin.*

Past Presidents.

Term began		*Expired*
1880	W. J. Beal, *of Michigan*	1882
1881	W. H. Brewer, *of Connecticut*	1884
1884	H. E. Alvord, *of New York*	1886
1886	E. L. Sturtevant, *of New York*	1887
1887	R. C. Kedzie, *of Michigan*	1889
1889	C. E. Bessey, *of Nebraska*	1891
1891	I. P. Roberts, *of New York*	1893
1893	W. Saunders, *of Ontario, Canada*	1895
1895	W. R. Lazenby, *of Ohio*	1897
1897	B. D. Halsted, *of New Jersey*	1899
1899	W. J. Beal, *of Michigan*	1901
1901	W. H. Jordan, *of New York*	1903
1903	William Frear, *of Pennsylvania*	1905
1905	H. P. Armsby, *of Pennsyvlania*	1907
1907	T. F. Hunt, *of Pennsyvlania*	1909
1909	S. M. Tracy, *of Mississippi*	1911
1911	Eugene Davenport, *of Illinois*	1913
1913	H. J. Waters, *of Kansas*	

Past Secretaries.

1880	E. L. Sturtevant, *of Massachusetts*	1882
1882	G. C. Caldwell, *of New York*	1883
1883	F. A. Gulley, *of Mississippi*	1885
1885	B. D Halsted, *of Iowa*	1886
1886	W. R. Lazenby, *of Ohio*	1891
1891	L O. Howard, *of District of Columbia*	1893
1893	W. Frear, *of Pennsylvania*	1895
1895	C. S. Plumb, *of Indiana*	1899
1899	T. F. Hunt, *of Ohio*	1900
1900	F. M. Webster, *of Illinois*	1905
1905	F. W Rane, *of Massachusetts*	1910
1910	E. W. Allen, *of District of Coulmbia*	

MEMBERSHIP OF THE SOCIETY.

Honorary Member.

1899. Hon. James Wilson, LL. D., *Traer, Iowa.*

Regular Members.

(Arranged Alphabetically.)

The prefixed date is the year of election.

1907. Edwin West Allen, B. S. (Mass. Agr. Coll. and Boston Univ., '85), Ph. D. (Göttingen, '90); *U. S. Dept. Agr., Washington, D. C.;* Asst Chem. Mass. Expt. Sta., '85–'88; Asst. Office Expt. Stas., '90–'93; Asst. Dir., do., '93—; Ed. Expt. Sta. Record, '95—.

1913. Harry Orson Allison, B. S. (Univ. Ill., '06), M. S. (do., '06); *Columbia, Mo.;* Instr. and Asst. in Anim. Husb., Univ. Ill, and Expt. Sta., '06–'10; Asst. Prof. Anim. Husb., Univ. Mo., '10–'12; Assoc. Prof., do., and Anim. Husb. Mo. Expt. Sta.. '12—.

1913. John W. Ames, B. S. (Case School Appl. Sci., '98), M. S. (do. '06); *Wooster, Ohio;* Chem., Ohio Expt. Sta., '99—.

1889. Henry Prentiss Armsby, B. S. (Worcester Poly. Inst., '71), Ph. B. (Sheffield Sci. School, '74), Ph. D. (Yale Univ., '79), LL. D. (Univ. Wis., '04); *State College, Pa.;* Chem. Conn. Expt. Sta., '77–'81; Vice Prin. Storrs Agr. School, '81–'83; Prof. Agr. Chem., Univ. Wis., '83–'87; Dir. Pa. Expt. Sta., '87–'07; Dean School of Agr., Penn. State College, '95–'02; Dir. Inst. Animal Nutrition, '07—.

1886. Joseph Charles Arthur, B. S. (Iowa State Coll., '72), M. S. (do., '77), D. Sc. (Cornell Univ., '86); *Lafayette, Ind.;* Instr. Biol., Iowa State Coll., '76–78; Instr. Bot., Univ. Wis., '79-'81; do., Univ. Minn., '82; Bot. N. Y. Expt. Sta., '84–'87; Prof. Bot., Purdue Univ., '87–'88; Prof. Veg. Phys. and Path. do., and Bot., Ind. Expt. Sta., '88—.

1906. Liberty Hyde Bailey, B. S. (Mich. Agr. Coll., '82), M. S. (do., '85), LL. D. (Univ. Wis., '07); *Ithaca, N. Y.;* Prof. Hort. and Landscape Gardening, Mich. Agr. Coll., '84–'88; Prof. Hort., Cornell Univ., '88–'03; Dir. Coll. Agr. and Expt. Sta., Cornell Univ., '03–'13.

1909. Walter Henry Beal, A. B. and M. E. (Va. Poly. Inst., '86); *Washington, D. C.*; Asst. Chem. Mass. Expt. Sta., '87–'91; Asst. Office of Expt. Stas., U. S. D. A., '91–'02; Chief of Editorial Division, do., '02—.

1879. William James Beal, A. B. (Univ. Mich., '59), A. M. (do., '63), Sc. B. (Harvard Univ. '65), Sc. M. (Univ. Chicago, '75), Ph.

D. (Univ. Mich., '80), D. Sc. (Mich. Agr. Coll., '05); *Amherst, Mass.*; Prof. Bot., Mich. Agr. Coll., '70–'72; Prof. Bot. and Hort., '72–'81; Prof. Bot. and Forestry, '81–'03; Prof. Bot., '03–'10; Prof. Emeritus, '10—.

1880. Charles Edwin Bessey, B. Sc. (Mich. Agr. Coll., '69), M. Sc. (Mich. Agr. Coll., '72), Ph. D. (State Univ. Iowa. '79), LL. D. (Iowa Grinnell Coll., '98); *Lincoln, Nebr.*; Prof. Bot., Iowa Agr. Coll., '70–'84; Prof. Bot., Univ Nebr., '84—; Acting Pres. Iowa Agr. Coll., '82; Acting Chancellor Univ. Nebr., '88–'91, and '99–'00; Dean Industrial Coll., Univ. Nebr., '84–'88, and '95—; Dean Coll. of Literature, Science and Arts, '88–'91; Dir. Nebr. Expt. Sta., '87–'89; Head Dean of Univ., '09—.

1912. Augustine Wilberforce Blair, B. S. (Haverford, '92), A. M. (do., '96); *New Brunswick, N. J.*; Prof. Chem., Guilford Coll., '96–'97; Asst. Chem., N. C. Expt. Sta., '97–'98; State Chem., N. C., '98–'99; Asst. Chem., Fla. Expt. Sta. and Univ. Fla., '99–'06; Chem., Fla. Expt. Sta., '06–'12; Assoc. Soil Chem., N. J. Expt. Sta., '12—.

1913. Maurice Adin Blake, B. S. (Mass. Agr. Coll., '04); *New Brunswick, N. J.*; Asst. Hort., R. I. Agr. Coll. and Expt. Sta., '04–'05; Instr. Hort., Mass. Agr. Coll., '05–'06; Hort., N. J. Expt. Stas., '06—.

1893. Henry Luke Bolley, B. S. (Purdue Univ., '88), M. S. (do., '89); *Agricultural College, N. Dak.*; Instr. Biol. and Asst. Bot. to Expt. Sta., Purdue Univ., '90; Prof. Bot. and Plant Path., N. Dak. Agr. Coll. and Bot. and Plant Path. of Expt. Sta. do., '90—.

1909. William Penn Brooks, B. Sc. (Mass. Agr. Coll., '75), Ph. D. (Halle, '97); *Amherst, Mass.*; Prof. Agr. Imp Coll. Agr., Sapporo, Japan, '77–'88; Prof. Bot., do., '81–'88; Pres., do., *ad interim* '80–'83, and '86–'87; Prof. Agr. and Agr., Mass. Agr. Coll. and Expt. Sta., '89–'09; acting Pres. and Dir., do., '05, '06; Dir. Expt. Sta., '06—.

1905. Burt C. Buffum, B. S. (Col. Agr. Coll., '90), M. S. (do., '93); *Worland, Wyo.;* Asst. Met. and Irr. Eng., Col. Agr. Coll., '90–'91; Prof. Hort. and Met., Univ. Wyo. and Bot. Wyo. Expt. Sta., '91–'92; Prof. Agr. and Hort., do., '91–'00; Vice Dir. do. Expt. Sta., '96–'00; Prof. Agr., Col. Agr. Coll., '00–'02; Dir. Wyo. Expt. Sta., and Prof. Agr. and Hort., Univ. Wyo., '02–'07; Plant Breeder and Mgr. Wyo. Seed Breeding Co., '07—.

1901. Edgar Allen Burnett, B. S. (Mich. Agr. Coll., '87); *Lincoln, Nebr.;* Asst. Mich. Agr. Coll., '89–'93; Prof. Anim. Husb., S. Dak. Agr. Coll., '96–'99; Prof. Anim. Husb., Univ. Nebr., '99–'07; Dir. Nebr. Expt. Sta., '01—; Dean Coll. Agr., '09—.

1908. Kenyon L. Butterfield, B. S. (Mich. Agr. Coll., '91), A. M. (Univ. Mich., '02); *Amherst, Mass.;* Supt. Mich. Farmers'

Institutes, '95–'99; Instr. Univ. Mich., '02; Pres. Rhode Island Coll., '03–'06; Pres. Mass. Agr. Coll. and Head Div. Rural Sociol., '06—.

1909. Frank Kenneth Cameron, A. B. (Johns Hopkins, '91), Ph. D. (do., '94); *Washington, D. C.;* Fellow Cornell, '94–'95; Assoc. Prof., Catholic Univ., '95–'97; Asst. Physical Chem., Cornell, '97–'98; Expert, U. S. D. A., '98–'99; Soil Chemist, do., '99—.

1908. Mark Alfred Carleton, B. S. (Kans. Agr. Coll., '87), M. S. (do., '93); *Washington, D. C.;* Asst. Bot., Kans. Expt. Sta., '92–'93; Cerealist, Bur. Plant Indus., U. S. D. A., '94–'12; Gen. Mgr., Penn. Chestnut Tree Blight Com., '12–'13; Cerealist, Bur. Plant Indus., U. S. D. A., '13—.

1905. Louis George Carpenter, B. S. (Mich. Agr. Coll., '79), M. S. (do., '84), LL. D (do., '07); *707 First Nat. Bank Bldg., Denver, Col.;* Asst. Prof., Mich. Agr. Coll., '85–'88; Irr. Eng., Col. Agr. Coll. and Expt. Sta., '88–'10; Dir. Expt. Sta. do., '99–'10; State Eng., '03–'05; Consulting Irrigation Engineer, '10—.

1901. Louis Adelbert Clinton, B. S. (Mich. Agr. Coll., '89), M. S. (do., '97); *U. S. Dept. Agr., Washington, D. C.;* Asst. to Dir. Mich. Expt. Sta., '89–'93; Asst. Prof. Agr., Clemson Coll., '93–'95; Asst. Agr., Cornell Expt. Sta., '95–'02; Dir. Storrs Expt. Sta. and Prof. Agr., Conn. Agr. Coll., '02–'12; Agriculturist, Bur. Plant Indus., '12—.

1910. John Waldo Connaway, D. V. S. (Chicago Vet. Coll., '90), M. D. (Univ. Mo., '91); *Columbia, Mo.;* Prof. Physiology. Univ. Mo., '91–'97; Vet. Expt. Sta., do., '97–'00; Prof, Compar. Med. and Vet. to Expt. Sta., Univ. Mo., '00—.

1910. Lee Cleveland Corbett, B. S. (Cornell Univ., '90), M. S. (do., '96); *Washington, D. C.;* Asst. Hort., Cornell Univ., '91–'93; Prof. Hort. and Forestry, S. Dak. Coll., '93–'95; do., Univ., W. Va. and Expt. Sta., '95–'01; Hort., U. S. Dept. Agr., '01–'13; Asst. Chief, Bur. Plant Indus., do., '13—.

1902. Charles Francis Curtiss, B. S. A. (Iowa State Coll., '87), M. S. A. (do., '93), D. Sc. (Mich. Agr. Coll., '07); *Ames, Ia.;* Asst. Dir. Iowa Expt. Sta., '91–'97; Prof. Agr. and Acting Dir., Iowa Expt. Sta., '97–'00; Prof. Agr. and Dir., do., '00–'02; Dean and Dir., '02—.

1911. William Haddock Dalrymple, M. R. C. V. S. England, '86; *Baton Rouge, La.;* Prof. Vet. Sci., La. State Univ., '89—; Vet., La. Expt. Sta., '89—.

1906. Eugene Davenport, B. S. (Mich. Agr. Coll., '78), M. S. (do., '81), M. Agr. (do., '95), LL. D. (do., '07); *Urbana, Ill.;* Prof. Agr., Mich. Agr. Coll., '89–'90; Dir. Coll. of Agr., Piracicaba, Brazil, '91–'92; Dean Coll. of Agr., Univ. Ill., '95—; Dir. Agr. Expt. Sta., '96—.

1913. Robert John H. DeLoach, A. B. (Univ. Ga., '98), A. M. (do., '06); *Experiment, Ga.;* Bot., Ga. Expt. Sta., '06–'08; Prof. Cotton Indus., Univ. Ga., '08–'13; Dir., Ga. Expt. Sta., '13—.

1911. William Rufus Dodson, B. S. (Univ. Mo., '90), A. B. (Harvard Univ., '94); *Baton Rouge, La.;* Asst. Biol., Univ. Mo., '90–'93; Prof. Bot., La. Univ., '94–'02; Asst. Dir., La. Expt. Stas., '02–'05; Dir., do., '05—; Dean, Coll. Agr., La., Univ., '09—.

1897. Benjamin Minge Duggar, B. S. (Miss. Agr. Coll., '91), M. S. (Ala. Poly. Inst., '92), A. B. (Harvard Univ., '94), A. M. (do., '95), Ph. D. (Cornell Univ., '98); *Missouri Botanical Garden, St. Louis, Mo.;* Asst. Ill. State Lab. Nat. Hist., '95–'96; Instr. Bot., Cornell Univ. and Asst. Cryptg. Bot., Expt. Sta., '96–'99; Asst. Prof. Bot., Cornell, '00–'01; Physiologist, U. S. Dept. Agr., '01–'02; Prof. Bot., Univ. Mo., '02–'07; Plant Physiologist, Coll. Agr. and Expt. Sta., Cornell Univ., '07–'12; Research Prof. Plant Physiol., Wash. Univ., '12—.

1910. John Frederick Duggar, B. S. (Miss. Agr. Coll., '87), M. S. (do., '88); *Auburn, Ala.;* Asst. in Agr., Tex. Agr. Coll., '87–'89; Asst. Dir., S. C. Expt. Sta., '90–'92; Agr. Editor Office Expt. Stas., U. S. D. A., '93–'95; Prof. Agr., Ala. Poly. Inst., '96—; Dir. Ala. Expt. Sta., 03—.

1913. Clarence Henry Eckles, B. S. A. (Iowa State Coll., '95), M. S. (do., '97); *Columbia, Mo.;* Instr. and Asst. in Dairying, Iowa Coll. and Expt. Sta., '96–'01; Asst. Prof. Dairy Husb. Univ. Mo., and Dairyman Mo. Expt. Sta., '01–'06; Prof. and Dairyman, do., '06—.

1903. Rollins Adams Emerson, B. S. (Univ. Nebr., '97); *Lincoln, Nebr.;* Hort. Editor Office Expt. Stas., U. S. Dept. Agr., '97–'98; Asst. Prof. Hort., Univ. Nebr., '99–'04; Prof. Hort., do., '05—; Hort. Expt. Sta., '98—.

1899. David Grandison Fairchild, B. S. (Kans. State Coll., '88), M. S. (do., '93); *Washington, D. C.;* Naples Zool. Sta., '93; Breslau and Berlin, '94; Bonn, '95; Buitenzorg Botanic Gardens, '96; Asst. Path. U. S. Dept. Agr., '89–'92; Special Agt. in charge Seed and Plant Introduction, '97–'98; Agr. Explorer, '98–'03; in charge Foreign Seed and Plant Introduction, U. S. Dept. Agr., '03—.

1880. William Gibson Farlow, A. B. (Harvard Univ., '66), M. D. (do., '70), LL. D. (do., '96; Univ. Glasgow, '01; Univ. Wis., '04); *24 Quincy St., Cambridge, Mass.;* Asst. Prof. Bot., Harvard Univ., '74–'79; Prof. Cryptg. Bot., do., '79—.

1909. Edward Holyoke Farrington, B. S. (Unvi. Me., '81), M. S. (Yale, '82); *Madison, Wis.;* Chem., Conn. State Expt. Sta., '83–'89; do., Ill. Expt. Sta., '90–'94; Assoc. in Dairy Husb., Wis. Univ. and Expt. Sta., '94–'00; Prof. Dairy Husb., do., '00—.

1890. Bernhard Edward Fernow (Münden Forest Acad. grad., '73) LL. D. (Univ. Wis., '97; Queen's '03); *Toronto, Can.;* Chief, Div. Forestry, U. S. Dept. Agr., '86–'98; Dir. N. Y. State Coll. of Forestry, '98–'03; Lecturer Yale Forestry School, '04; Prof. of Forestry, Univ. of Toronto, '07—.

1911. MARTIN LUTHER FISHER, B. S. (Purdue Univ., '03), M. S. (Univ. Wis., '11); *Lafayette, Ind.;* Asst. in Agr., Purdue Univ., '03–'04; Instr. Agr., do., '04–'06; Asst. Prof. Agron., do., '06–'08; Assoc. Prof. Agron., do., '08–'10; Prof. Crop Prod., do., '10—; Asst. Agr., Indiana Expt. Sta., '03–'10; Assoc. in Crops, do., '10—.

1910. ERNEST BROWNING FORBES, B. Sc. (Univ. Ill., '97), B. S. Agr. (do., '02), Ph. D. (Univ. Mo., '08); *Wooster, Ohio;* Zool. Asst., Ill. Biol. Sta., '94–'96; Asst. to State Ento. of Minn., '97–'98; Acting State Ento. Minn., '01; Asst. in Anim. Husb., Ill. Expt. Sta., '01–'02; Instr. Anim. Husb., Univ. Ill., '02–'03; Asst. Prof. Anim. Husb., Univ. Mo., '03–'07; Chief in Nutr. Ohio Expt. Sta., '07—.

1908. STEPHEN ALFRED FORBES, Ph. D. (Ind. Univ., '84), LL. D. (Univ. Ill., '05), *Urbana, Ill.;* Prof. Zool., Univ. Ill., '84–'09; State Ento. Ill., '82—; Dir. Ill. State Lab. of Nat. Hist., '77—; Dean Coll. of Sci., Univ. of Ill., '88—.

1911. GEORGE STRONACH FRAPS, B. S. (N. C. Agr. Coll., '96), Ph. D. (Johns Hopkins Univ., '99); *College Station, Tex.;* Asst. Prof. Chem., N. C. Agr. Coll., and Asst. Chem. in Expt. Sta., '99–'03; Asst. Chem., Tex. Expt. Sta., '03–'04; Assoc. Chem., do., '04–'05, Chem., do., '05—; Assoc. Prof. Chem., Tex. Agr. Coll., '03–'05; Acting Prof., do., '05–'06; Assoc. Prof. Agr. Chem., do., '06—; State Chem., '06—.

1888. WILLIAM FREAR, A. B. (Bucknell Univ., '81), Ph. D. (Ill. Wesleyan Univ., '83); *State College, Pa.;* Asst. Sci., Bucknell Univ., '81–'83; Asst. Chem. U. S. Dept. Agr., '83–'85; Prof. Agr. Chem., Pa. State Coll., '85—; Vice Dir. and Chem., Pa. Expt. Sta., '87—.

1913. JONS AUGUST FRIES, B. S. (Pa. State Coll., '99), M. S. (do., '06); *State College, Pa.;* Asst. Chem., Pa. Expt. Sta., '89–'98; Expert Asst. Anim. Nutr., do., '98–'08; Asst. Dir. Inst. Anim. Nutr., '08—.

1908. BEVERLY THOMAS GALLOWAY, B. S. (Univ. Mo., '84), LL. D. (do., '02); *Washington, D. C.;* Asst. Hort., Univ. Mo., '84–'87; Asst. Path., U. S. Dept. Agr., '87–'88; Path. and Chief, Div. Veg. Path. and Physiol., do., '88–'01; Chief Bur. Plant Indus., do., '01–'13; Asst. Sec. of Agr., '13—.

1894. HARRISON GARMAN, *Lexington, Ky.;* Asst. State Lab. Nat. Hist., Ill., '83–'89; Asst. Prof. Zool., Univ. Ill., '85–'89; Ento. and Bot., Ky. Expt. Sta., '89—; State Ento., Ky. '97—.

1894. CHARLES CHRISTIAN GEORGESON, B. S. (Mich. Agr. Coll., '78), M. S. (do., '82); *Sitka, Alaska;* Asst. Ed. of *Rural New Yorker*, '78–'80; Prof. Agr. and Hort., Tex. Agr. Coll., '80–'83; Prof. Agr., Coll. of Agr., Imperial Univ., Tokyo, Japan, '86–'89; Prof. Agr., Kans. State Agr. Coll., '90;–'97; Special Agt. U. S. Dept. Agr., Dairy Industry, Denmark, '93; Asst. Agros-

tologist, U. S. Dept. Agr., '97–'98; Special Agt. in charge Alaska Expt. Sta., do., '98—.

1893. Clarence Preston Gillette, B. S. (Mich. Agr. Coll., '84), M. S. (do., '88); *Fort Collins, Col.;* Asst. Zool., Mich. Agr. Coll., '87–'88; Ento. Iowa Expt. Sta., '88–'91; Prof. Zool. and Ento., Col. Agr. Coll. and Ento. Expt. Sta., do., '91—; Dir. Expt. Sta., do., '10—.

1911. Arthur Goss, B. S. (Purdue Univ., '88), M. S. (do., '95); *Lafayette, Ind.;* Asst. Chem., Ind. Expt. Sta., '88–'92; Asst., Ind. Weather Serv., '89–'92; Prof. Chem., N. Mex. Agr. Coll., and Chem. in Expt. Sta., '92–'03; Vice-Dir., N. Mex. Expt. Sta., '95–'00; Dir., Ind. Expt. Sta., '03—

1909. Harry Sands Grindley, B. S. (Univ. Ill., '88), Sc. D. (Harvard, '94; *Urbana, Ill.;* Asst. Chem., Univ. Ill., '88–'92; Asst. Chem., Harvard, '92–'93; Fellow Harvard, '93–'94; Instr. Chem., Univ. Ill., '94–'95; Asst. Prof Chem., do., '95–'99; Assoc. Prof. Chem., do., '99–'04; Prof. and Dir. Chem. Lab. do., '04–'07; Prof. An. Chem., do., and Chief An. Chem., Expt. Sta., '07—.

1909. Theophilus L. Hacker, *University Farm, St. Paul, Minn.;* in charge Dairy Husb., Minn. Univ. and Expt. Sta., '92–'07; Prof. Dairy Husb. and Anim. Nutrition, do., '07–'09; Prof. Dairying, Anim. Husb. and Anim. Nutrition, do., '10—.

1880. Byron David Halsted, B. S. (Mich. Agr. Coll., '71), M. S. (do., '74), Sc. D. (Harvard Univ., '78); *New Brunswick, N. J.;* Ed. *American Agriculturist*, '79–'85; Prof. Bot., Iowa State Coll., '85–'89; Prof. Bot. and Hort., Rutgers Coll., '89–'10; Bot., N. J. Expt. Sta, '89—.

1902. Niels Ebbensen Hansen, B. S. (Iowa State Coll., '87), M. S. (do., '95); *Brookings, S. Dak.;* Asst. Prof. Hort., Iowa State Coll., '91–'95; Prof. Hort. and Forestry, S. Dak Agr. Coll., and Hort., Expt. Sta., '95—.

1910. Joseph Nelson Harper, B. S. (Miss. Agr. Coll., '95), M. A. (Ky. Agr. Coll., '06); *Clemson College, S. C.;* Dairy Husb., Miss. Expt. Sta., '95; Dairy Husb., Ky. Expt. Sta., '96–'98; Agriculturist, do, '98–'05; Dir. and Agron., S. C. Expt. Sta., '06—.

1911. Edwin Bret Hart, B. S. (Univ. Mich., '97); *Madison, Wis.;* Asst. Chem., N. Y. Expt. Sta., '97–'00; Assoc. Chem., do., '06; Prof. Agr. Chem., Univ. Wis., and Chem., Wis. Expt. Sta., '06—.

1910. Burt Laws Hartwell, B. S. (Mass. Agr. Coll. and Boston Univ., '89), M. S. (Mass. Agr. Coll., '00), Ph. D. (Univ. Pa., '03); *Kingston, R. I.;* Asst. Chem., Mass. Expt. Sta, '89–'91; Asst. Chem., R. I. Expt. Sta., '91–'03; Assoc. Chem., do., '03–'07; Chem., do., '07—; Prof. Agr. Chem., R. I. State Coll., '08—; Dir., R. I. Expt. Sta., '13—.

1905. Willet Martin Hays, B. Agr. (Iowa State Coll., '85), M. Agr.

(do., '86); *Washington, D. C.;* Asst. Iowa Agr. Coll., '86; Assoc. Ed., *Prairie Farmer*, '87; Asst. in Agr., Iowa Agr. Coll., '88–'89; Prof. Agr. and Agriculturist, Minn. Agr. Coll. and Expt. Sta., '90–'91; Prof. Agr. and Agriculturist, N. Dak. Agr. Coll. and Expt. Sta., '92–'93; Prof. Agr. and Agriculturist, Minn. Agr. Coll. and Expt. Sta., '93–'04; Asst. Sec. of Agr., U. S. Dept. Agr., '04—'13.

1911. HARRY HAYWARD, B. S. (Cornell Univ., '94), M. S. (do., '01); *Newark, Del ;* Asst. Prof. Dairy Husb., Pa. State Coll., '97–'02; Assoc. Prof. An. and Dairy Husb., N. H. Agr. Coll., '02–'03; Asst. Chief Dairy Div., U. S. Dept. Agr., '03; Dir. Agr. Dept., Mount Hermon School, '03–'06; Dean Agr. Dept., Del. Coll., and Dir. Del. Expt. Sta., '06—.

1909. WILLIAM PARKER HEADDEN, A. B. (Dickinson, '72), A. M. (do., '75), Ph. D. (Univ. Giessen, '74); *Fort Collins, Col.;* Asst., Univ. Pa., '74–'76; Prof. Chem., Md. Agr. Coll., '80–'84; do., Univ. Denver, '84–'89; do., S. Dak. School of Mines, '89–'91; Dean, do., '92– 93; Prof. Chem. and Geol., Col. Agr. Coll., and Chem., Expt. Sta., '93—.

1909. ULYSSES PRENTISS HEDRICK, B. S. (Mich. Agr. Coll., '93), M. S. (do., '95); *Geneva, N. Y.;* Asst. Hort., Mich. Agr. Coll., '93–'95; Prof. Bot. and Hort., Ore. Agr. Coll., and Hort. Expt. Sta., '95–'97; Prof. Bot. and Hort., and Hort., Expt. Sta., Utah, '97–'99; Prof. Hort., Mich. Agr. Coll., '99–'05; Hort., N. Y. Expt. Sta. '05—.

1880. EUGENE WALDEMAR HILGARD, Ph. D. (Heidelberg, '53), LL. D. (Columbia Univ., '87); *Berkeley, Cal.;* State Geol., Miss., '58–'72; Prof. Chem., Univ. Miss., '66–'73; Prof. Geol. and Nat. Hist., Univ. Mich., '73–'75; Prof. Agr., Univ. Cal., and Agriculturist, Expt. Sta., '75–'06; Dir. Cal. Expt. Sta., '88–'06; Prof. Emeritus, '06—.

1905. JOSEPH LAWRENCE HILLS, B. S. (Mass. Agr. Coll. and Boston Univ., '81), D. Sc. (honorary, '03, Rutgers Coll.); *Burlington, Vt ;* Asst. Chem., Mass. Expt. Sta., '82–'83; Asst. Chem., N. J. Expt. Sta., '84–'85; Chem, Phos. Mining Co. Ltd., Beaufort, S. C., '85–'88; Chem., Vt. Expt. Sta., '88–'98; Dir., do., '98—; Prof. Agr. Chem., Univ. Vt. '93—; Dean, Dept. Agr., do., '98—.

1911. CYRIL GEORGE HOPKINS, B. S. (S. Dak. Agr. Coll., '90), M. S. (Cornell Univ., '94), Ph. D. (do., '98); *Urbana, Ill.;* Asst. Chem., S. Dak. Agr. Coll. and Expt. Sta., '90–'92; do., Cornell Univ., '92–'93; Acting Prof. Pharm., S. Dak. Agr. Coll., '93–'94; Chem., Ill. Expt. Sta., '94—; Prof. Agron., Univ. Ill., '00—.

1889. LELAND OSSIAN HOWARD, B. S. (Cornell Univ., '77), M. S. (do., '86), Ph. D. (Georgetown Univ., '96); *Washington, D. C.;* Asst. Ento., U. S. Dept. Agr., '78–'94; Chief Ento., do., '94—; Perm. Sec., A. A. A. S.,'98—.

1912. WALTER LAFAYETTE HOWARD, B. Agr., B. S. (Univ. Mo., '01),

M. S. (do., '03), Ph. D. (Univ. Halle-Wittenberg, '06); *Columbia, Mo.;* Asst. in Hort., Univ. Mo., '01–'03; Instr., do., '03–'04; Asst. Prof., do., '05–'08; Sec., Mo. State Board Hort., '08–'12.; Prof. Hort., Univ. Mo., '08—.

1903. Thomas Forsyth Hunt, B. S. (Univ. Ill., '84), M. S. (do., '92), D. Agr. (do., '04), D. Sc. (Mich. Agr. Coll., '07); *Berkeley, Cal.;* Asst. State Ento. of Ill., '85–'86; Asst. Agr., Univ. Ill., '86–'88; Asst. Agr., Ill. Expt. Sta., '88–'91; Prof. Agr., Pa. State Coll., '91–'92; Prof. Agr., Ohio State Univ., '92–'95; Dean Coll. Agr., Ohio State Univ., '95–'03; Prof. Agron., Cornell Univ., and Agron., Expt. Sta., '03–'06; Dean Coll. Agr., and Dir. Agr. Expt. Sta., Pa. State Coll., '06–'12; Dean Coll. Agr., Univ. Cal., and Dir. Expt. Sta., '12—.

1908. William Daniel Hurd, B. S. (Mich. Agr. Coll., '99), M. Agr. (do., '08); *Amherst, Mass.;* Instr., Lansing High School, '99–'01; Prof. Hort., Briarcliff Agr. School, '01–'03; Prof. Agr., Univ. Me., '03–'05; Acting Dean, Coll. of Agr., do., '05–'06; Dean, '06–'09; Dir. of Short Courses Mass. Agr. Coll., '09—.

1898. Henry Clay Irish, B. S. (S. Dak. Agr. Coll., '91), M. S. (Iowa State Coll., '98); *Missouri Botanical Garden, St. Louis, Mo.;* Hort. Asst., Mo. Bot. Gard., '95–'02; Supt., do '03—.

1908. Myer Edward Jaffa, Ph. B. (Univ. Cal., '77), M. S. (do., '96); *Berkeley, Cal.;* Asst. Chem., U. S. Census, '79–'80; Asst. Agr. Dept., Univ. Cal., '80–'81; Asst. Chem., Northern Transcontinental Surv., '81–'83; Asst. Chem., Univ. Cal., '83–'96; Asst. Prof. Agr., do. '96–'06; do., Nutr. '06–'08; Prof. Nutr., do., '08—.

1885. Edward Hopkins Jenkins, A. B. (Yale Univ., '72), Ph. D. (do., '79); *New Haven, Conn.;* Chem., Conn. Expt. Sta., '76–'00; Vice Dir., do., '82–'00; Dir., do., '00—; Treas., do., '01—; Dir., Storrs Expt. Sta., '12—.

1894. Whitman Howard Jordan, B. S. (Univ. Me., '75), M. S. (do., '79), D. Sc. (do., '96), LL. D. (Mich. Agr. Coll., '07; *Geneva, N. Y.;* Asst. Chem., Conn. Expt. Sta., '78–'79; Instr. Agr., Univ. Me., '79–'80; Prof. Agr. and Agr. Chem., Pa. State Coll., '81–'85; Dir., Me. Expt. Sta., '85–'96; Prof. Agr., Univ. Me., '94–'96; Dir., N. Y. Expt. Sta., '96—.

1912. John Chester Kendall, B. S. (N. H. Coll., '02); *Durham, N. H.;* Instr. in Dairy Husb., N. C. Agr. Coll., '02–'03; Asst. Prof. of Dairy Husb., do., '03–'06; State Dairy Comr., Kans., '06–'07; Prof. of Dairy Husb., Kans. Agr. Coll., '08–'10; Dir., N. H. Expt. Sta., '10—; Dir. of Ext. Work., N. H., '11—.

1909. Benjamin Wesley Kilgore, B. S. (Miss. Agr. Col., '88), M. S. (do., '90); *Raleigh, N. C.;* Asst. Chem., Miss. Agr. Coll., '88–'89; do., N. C. Expt. Sta., '89–'97; Prof. Chem., Miss. Agr. Coll. and Agr Expt. Sta., '97–'99; State Chem., N. C., '99—; Dir., N. C. Expt. Sta., '01–'07; do., '13—.

1911. Henry Granger Knight, A. B. (Univ. Wash., Seattle, '02),

A. M. (do., '04); *Laramie, Wyo.;* Asst. Chem., Univ. Wash., '00–'01; Instr., do., '01–'02; Asst. Chem., Univ. Chicago, '02–'03; Asst. Prof. Chem., Univ. Wash., '03–'04; Prof. Chem., Univ. Wyo., and State Chem., '04—; Dir., Wyo. Expt. Sta., '10—.

1889. Edwin Fremont Ladd, B. Sc. (Univ. Me., '84); *Agricultural College, N. Dak.;* Asst. Chem., N. Y. State Expt. Sta., '84–'87; Chief Chem., do., '87–'90; Prof. Chem., N. Dak. Agr. Coll. and Chem. Expt. Sta., '90—; Food Comr. and State Chem., N. Dak., '00—.

1883. William Rane Lazenby, B. Agr. (Cornell Univ., '74), M. Agr. Iowa Agr. Coll., '87); *Columbus, Ohio;* Instr. Hort., Cornell Univ., '74–'77; Asst. Prof. Hort., do., '77–'81; Prof. Hort. and Bot., Ohio State Univ., '81–'82; Dir., Ohio Expt. Sta., '82–'87; Prof. Hort. and Forestry, Ohio State Univ., '82–'09; Prof. Forestry, do., '09—.

1899. Joseph Bridgeo Lindsey, B. Sc. (Mass. Agr. Coll., '83), Ph. D. (Univ. Göttingen, '92); *Amherst, Mass.;* Asst. Chem., Mass. State Expt. Sta., '83–'85; Commercial Chem., '85–'89; Assoc. Chem., Mass. State Expt. Sta., '92–'95; Head Dept. Foods and Feeding, Hatch Expt. Sta., '95–'07; Chem., Mass. Expt. Sta., '07—; Vice Dir., do., '09—; Head Dept. Chem., Mass. Agr. Coll. and Goessmann Prof. of Agr. Chem., '11—.

1911. Frederick Bloomfield Linfield, B. S. A. (Ontario Agr. Coll., '91); *Bozeman, Mont.;* Asst. in Dairying, Ontario Agr. Coll., '92–'93; Prof. Anim. Indus. and Dairying, Utah Agr. Coll., '93–'02; Prof. Agr., Mont. Agr. Coll., '02—; Acting Dir., Mont. Expt. Sta., '03; Dir., do., '04—.

1912. Charles Bernard Lipman, B. Sc. (Rutgers Coll., '04), M. Sc. (do., '09), M. S. (Univ. Wis., '09), Ph. D. (Univ. Cal., '10); *Berkeley, Cal.;* Instr. in Soil Bact., Univ. Cal., '09–'10; Asst. Prof. Soils, do., '10–'12; Assoc. Prof. of Soils, do., and Soil Chem. and Bact., Cal. Expt. Sta., '12—.

1909. Jacob G. Lipman, B. Sc. (Rutgers, '98), A. M. (Cornell, '00), Ph. D. (do., '03); *New Brunswick, N. J.;* Asst. Chem., N. J. Expt. Sta., '98–'99; Fellow Chem., Cornell, '01; Soil Chem. and Bact., N. J. Expt. Sta., '01—; Asst. Prof. Agr., Rutgers, '06–'07; Assoc., do., '07–'10; Prof. Soil Chem. and Bact., '10—; Dir., N. J. Expt. Stas., '11—.

1911. Edward Read Lloyd, B. S. (Ala. Poly. Inst., '87), M. S. (do., '88); *Agricultural College, Miss.;* Prof. Agr., Miss. Agr. Coll., '00–'05; Dir. Farmers' Insts., do., '06–'10; Vice Dir. and Anim. Husb., Miss. Expt. Sta., '10–'12; Dir., do., '12—.

1911. Charles Alfred Lory, B. Ped. (State Normal School, Greeley, Col., '98), B. S. (Univ. Col., '01), M. S. (do., '02), LL. D. (do., '09); *Fort Collins, Col.;* Asst. in Physics, Univ. Col., '99–'02; Prin. Cripple Creek High School, '02–'04; Acting Prof. Phy-

sics, Univ. Col., '04–'05; Prof. Physics and Elect. Engin., Col. Agr. Coll., '07–'09; Pres., do., '09—.

1899. Robert Hills Loughridge, B. S. (Univ. Wis., '71), Ph. D. (do., 76); *Berkeley, Cal.;* Asst. Prof. Chem., Univ. Miss., '72–'74; Asst. State Geol., Miss., '72–'74; do., Ga., '74–'78; do., Ky., '82–'85; Prof. Agr. Chem., S. C. Coll., '85–'90; Asst. Prof. Agr. Chem. and Geol., Univ. Cal., '91–'08; Assoc. Prof., do., '08–09; Emeritus Prof. Agr. Chem., do., '09—.

1901. Thomas Lyttleton Lyon, B. S. A. (Cornell Univ., '91), Ph. D. (Gottingen, '94); *Ithaca, N. Y.;* Instr. Chem., Univ. Nebr., '91–'93; Asst. Chem., Nebr. Expt. Sta., '94–'95; Assoc. Prof. Agr., Univ. Nebr., '95–'99; Prof. Agr., do., and Assoc. Dir. Expt. Sta., '99–'06; Prof. Expt. Agron., Cornell Univ. and Expt. Sta., '06—.

1911. Arthur Gillett McCall, B.S. Agr. (Ohio State Univ., '00); *Columbus, Ohio;* Asst., Bur. Soils, U. S. Dept. Agr., '00–'04; Asst. Prof. Agron., Ohio State Univ., '04–'05; Assoc. Prof. Agron., do., '05–'06; Prof. Agron., do., '06—.

1911. Charles Edward Marshall, Ph. B. (Univ. Mich., '95), Ph. D. (do., '02); *Amherst, Mass.;* Asst. Bact., Univ. Mich., '93–'96; do., Mich. Expt. Sta., '96–'98; Bact. and Hygienist, do., '98–'12; Sci. and Vice Dir., do., '08–'12; Prof. Bact. and Hyg., Mich. Agr. Coll., '03–'12; Dir. Graduate School and Prof. of Microbiol., Mass. Agr. Coll., '12—.

1911. Frederick Rupert Marshall, B. S. Agr. (Ontario Agr. Coll. '99), B. S. A. (Iowa State Coll., '00); *Washington, D. C.;* Asst. Prof. Anim. Husb., Iowa State Coll., '01–'03; Prof. Anim. Husb., Tex. Agr. Coll., '03–'07; Prof. Anim. Husb., Ohio State Univ., '07–'12; Prof. Anim. Indus., Univ. Cal., and Anim. Husb., Cal. Expt. Sta., '12–'13; Senior Anim. Husb., Bur. Anim. Indus., U. S. D. A., '13—.

1911. David William May, B. Agr. (Univ. Mo., '94), M. Agr. (do., '96); *Mayaguez, P. R.;* Asst. Agr., Missouri Expt. Sta., '97; Sci. Asst. Office Expt. Stas., U. S. D. A., '00–'02; Anim. Husb., Ky. Expt. Sta., '02–'04; Special Agt. in Charge, P. R. Expt. Sta., '04—.

1905. Lucius Herbert Merrill, B. S. (Univ. Me., '83), D. Sc. (honorary, do., '08); *Orono, Me.;* Chem., Me. Expt. Sta., '86–'08; Prof. Biol. Chem., Univ. Me., '98–'07; Prof. Biol. and Agr. Chem., do., '07—.

1909. Merritt Finley Miller, B. S. Agr. (Ohio State Univ., '00), M. S. A. (Cornell Univ., '01); *Columbia, Mo.;* Asst. Bur. Soils, U. S. Dept. Agr., '01–'02; Instr. Agron., Ohio State Univ., '02–'03; Asst. Prof., do., '03–'04; Prof. Agron., and Agron., Univ. Mo. and Expt. Sta., '04—.

1910. George Thomas Moore, B. S. (Wabash Coll., '94), A. B. (Harvard Univ., '95), A. M. (do., '96), Ph. D. (do., '00); *Missouri Botanical Garden, St. Louis, Mo.;* in charge Bot. Dept., Dart-

mouth Coll., '99–'01; Physiol. and Algologist, Bur. Plant Indus., U. S. Dept. Agr., '01–'02; in charge Lab. Plant Physiol., do., '02–'05; Prof. Plant Physiol. and Applied Bot., Shaw School of Bot., Mo. Bot. Gard., '09–'12; Dir., Mo. Bot. Gard., '12—.

1900. John Harcourt Alexander Morgan, B. S. A. (Univ. Toronto, '89); *Knoxville, Tenn.;* Prof. Ento. and Hort., La. State Univ., '89–'93; Prof. Zool. and Ento., do., '93–'04; Ento., La. Expt. Stas., '89–'04; Dir. Gulf Biol. Sta., '99–'05; Dir. Tenn. Expt. Sta., '05—.

1911. Fred Winslow Morse, B. S. (Worcester, '87), M. S. (do., '00); *Amherst, Mass.;* Asst. Chem., Mass. Expt. Sta., '87–'88; do., N. H. Expt. Sta., '88–'89; Chem., do., 89–'09; Vice Dir. do., '96–'09; Prof. Chem., N. H. Agr. Coll., '90–'09; Research Chem., Mass. Expt. Sta., '10—.

1912. Warner Jackson Morse, B. S. (Univ. Vt., '98), M. S. (do., '03), Ph. D. (Univ. Wis., '12); *Orono, Me.;* Teacher Nat. Sci., Montpelier Seminary, 99–'01; Asst. Bot., Vt. Expt. Sta. '01–'06; Instr. Bot., do., '01–'05; Asst. Prof. Bact., do., 05–'06; Plant Path., Me. Expt. Sta., '06—.

1909. Frederick Blackmar Mumford, B. S. (Mich. Agr. Coll., '91), M. S. (do., '93); *Columbia, Mo.;* Asst. Mich. Expt. Sta., '91–'95; Asst. Prof. Agr., Mich. Agr. Coll., '93–'95; Prof. Agr., Univ. Mo., 95–'04; Acting Dean Coll. Agr., Univ. Mo., and Acting Dir., Mo. Expt. Sta. '03–'05; Prof. Anim. Husb., Univ. Mo., '04—; in charge Anim. Husb. Dept., Mo. Expt. Sta., '06—; Dean Agr. and Dir. Expt. Sta., '09—.

1901. Herbetrt Windsor Mumford, B. S. (Mich. Agr Coll.,'91); *Urbana, Ill.;* Instr., Mich. Agr. Coll., and Asst., Expt. Sta., '95–'96; Asst. Prof. Agr. and Anim. Husb., do., '96–'99; Prof. Agr. do., '99–'01; Prof. Anim. Husb., Univ. Ill., and Chief in Anim. Husb., Ill. Expt. Sta. '01—.

1913. Martin Nelson, B. S. A. (Univ. Wis. '05), M. S. (do., '06); *Fayetteville, Ark.;* Adj. Prof. Field Crops and Soils Univ. Nebr. and Expt. Sta., '06–'07; Asst. Prof., do., '07–'08; Prof. Agron. and Agron., Univ. Ark. and Expt. Sta., '08–'13; Dean Univ. Ark. and Dir. Expt. Sta., '13—.

1893. Herbert Osborn, B. S. (Iowa State Coll., '79), M. S. (do., '80); *Columbus, Ohio;* Asst. Zool. and Ento., Iowa State Coll., '79–'83; Asst. Prof., do., '83–'85; Prof., do., '85–'98; Prof. Zool. and Ento., Ohio State Univ., '98—.

1893. Louis Herman Pammel, B. Agr. (Univ. Wis., '85), M. S. (do., '89), Ph. D. (Wash. Univ., '99); *Ames, Iowa;* Asst., Shaw School of Bot., '86–'89; Tex. Agr. Expt. Sta., '89; Prof. Bot., Iowa State Coll., '89—; Bot. Iowa Expt. Sta., '92—.

1893. Henry Jacob Patterson, B. S. (Pa. State Coll., '86); *College Park, Md.;* Asst. Chem., Pa. Expt. Sta., '86–'88; Chem., Md. Expt. Sta , '88–'98; Dir. and Chem., do., '98; Pres. Md. Agr. Coll. '13—.

1910. Raymond Pearl, A. B. (Dartmouth Coll., '99), Ph. D. (Univ. Mich., '02); *Orono, Me.;* Asst. Zool., Univ. Mich., '99–'02; Instr. Zool., do., '02–'06; Instr. Zool., Univ. Penn., '06–'07; Biol. and Head Dept. Biol., Me. Expt. Sta. '07—; Assoc. Ed. *Zool. Jahresber*, '06–'08; *Biometrika*, '06–10, *Zentbl. Allg. u. Expt. Biol.*, '10—.

1909. Raymond Allen Pearson. B. S. A. (Cornell Univ., '94), M. S. A. (do., '99); *Ames, Iowa;* Asst. Chief Dairy Div., U. S. Dept. Agr., '95–'02; Mgr. Walker-Gordon Lab. Co., N. Y. and Phila., '02–'03; Prof. Dairy Ind., Cornell Univ., '03–'07; N. Y. Comr. Agr., '07–'12; Pres. Iowa State Coll., '12—.

1910. William Robert Perkins, B. S. (Miss. Agr. Coll., '91); M. S. (do., '94); *Deeson, Miss.;* Asst. State Chem., Miss., '91–'94; Chem., Miss., Expt. Sta., '94–'06; Asst. Prof. Agr., Miss. Agr. Coll., '06; Agron., Miss. Expt. Sta., '07–'10; Dir. Agr. Dept., and Prof. Agron., Clemson Coll., '10–'11; Supt. Syndicate Farm, Deeson, Miss., '11—.

1909. Charles Vancouver Piper, B. S. (Univ. Wash., '85), M. S. (do., '92; Harvard, '00); *Washington, D. C.;* Prof. Ento., Wash. State Coll., '92–'93; Prof. Bot. and Zool., do., and Bot. and Ento., Expt. Sta., '93–'03; Syst. Agrostologist, U. S. Dept. Agr., '03–'04; Agrostologist, do., '05—.

1890. Charles Sumner Plumb, B. S. (Mass. Agr. Coll., '82); *Columbus, Ohio;* Asst. Ed. *Rural New Yorker*, '83–'84; First Asst., N. Y. Expt. Sta., '84–'87; Prof. Agr., Univ. Tenn., and Asst. Dir., Expt. Sta., '87–'90; Prof. Agr. Sci., Purdue Univ., '90 '94; Prof. Anim. Indus. and Dairying, do., '94–'00; Prof. Anim. Indus., do., '00–'02; Vice Dir., Ind. Expt. Sta., '90–'91; Dir., do., '91–'02; Prof. Anim. Indus., Ohio State Univ., '02—.

1894. Frank William Rane, B. Agr. (Ohio State Univ., '91), M. Sc. (Cornell Univ., '92); *State House, Boston, Mass.;* Hort. and Microscopist, W. Va. Expt. Sta., '92–'95; Prof. Agr. and Hort., W. Va. Univ., '93–'95; Prof. Agr. and Hort., N. H. Coll., '95–'98; Prof. Hort., do., '98–'00; Prof. Forestry and Hort., do., '00–'06; State Forester, Mass., '06—.

1913. James Burness Rather, B. S. (Tex. Agr. Coll., '07), M. S. (do., '11); *College Station, Tex.;* Asst. State Chem. Tex., '07–'09; Asst. Chem. Tex. Expt. Sta., '08–'12; First Asst. Chem., do., '12—.

1913. George Matthew Reed, A B. (Geneva Coll., '00), A. M. (Univ. Wis., '04), Ph. D. (do., '07); *Columbia, Mo.;* Prof. Nat. Sci., Amity Coll., '00–'03; Asst. in Bot., Univ. Wis. '04–'07; Instr. in Bot., do., '07; Asst. Prof. Bot., Univ. Mo., '07–'12; Prof. Bot , do., '12—; Bot Mo. Expt. Sta., '09—.

1881. Isaac Phillips Roberts, M. Agr. (Iowa State Coll., '75); *Palo Alto, Cal.;* Prof. Agr. and Dean Agr., Cornell Univ., '73–'94; Dir. Cornell Expt. Sta., '88–'03; Dir. Col. Agr., '94–'03; Prof. Emeritus and lecturer, '03—.

1893. James Wilson Robertson, LL. D. (Toronto Univ., and Queen's Univ., '03; Univ. New Brunswick, '04); *Box 540, Ottawa, Can.;* Prof. Dairying, Ontario Agr. Coll., '86–'90; Dairy Comr. Canada, '90–'95; Comr. Agr. and Dairying, 95–'04; Prin., MacDonald Coll., '05–'09; Chairman Royal Com. on Indus. Training and Tech. Ed., '10—.

1909. Peter Henry Rolfs, B. S., M. S. (Iowa State Coll. '91); *Gainesville, Fla.;* Asst. Bot., Iowa State Coll., '91; Ento. and Bot., Fla. Expt. Sta., '92–'98; Bot. and Hort., do., '98–'99; Bot. and Bact., S. C. Expt. Sta., '99–'01; Plant Path. in charge Sub-Trop. Lab., U. S. Dept. Agr., Miami, Fla., '01–'06; Dir., Fla. Expt. Sta., '06—; State Supt. Farmers' Institutes, '07—.

1911. George McCullough Rommel, B. S. (Iowa Wesleyan Univ., '97), B. S. A. (Iowa State Coll., '99); *Washington, D. C.;* Expert in Anim. Husb., Bur. Anim. Indus., U. S. Dept. Agr., '01–'05; Anim. Husb., do., '05–'09; Chief, Anim. Husb. Div., do , '10—.

1909 Harry Luman Russell, B. S. (Univ. Wis., '88), M. S. (do., '90), Ph. D. (Johns Hopkins, '92); *Madison, Wis.;* Fellow Univ. Wis., '88–'90; Fellow Univ. Chicago, '92–'93; Asst. Prof. Bact., Univ. Wis., '93–'96; Prof. do., '96–'97; Bact., Wis. Expt. Sta., '93–'97; Dir. State Hygienic Lab., '03–'07; Dean Coll. of Agr. and Dir. Expt. Sta., Univ. Wis., '07—.

1912. Walter George Sackett, B. S. (Univ. Chicago, '02); *Fort Collins, Col.;* Prof. Nat. Sci., Meredith Coll., '02–'04; Special Agt., U. S. Dept. Agr., '04; Instr. Bact. and Hyg., Mich. Agr. Coll., '04–'06; Asst. Prof. Bact. and Hyg., do., and Asst. Bact. Mich. Expt. Sta., '06–'08; Bact., Col. Expt. Sta., '08—.

1908. Ezra Dwight Sanderson, B. S. (Mich. Agr. Coll., '97), B. S. Agr. (Cornell, '98); *Morgantown, W. Va.;* Asst. State Ento. Md., '98–'99; Ento., Del. Expt. Sta., and Assoc. Prof. Zool., Del. Coll., '99–'02; State Ento. Tex., and Prof. Ento., Tex. A and M. Coll., '02–'04; Ento., N. H. Expt. Sta., and Prof. Ento. and Zool., N. H. Coll., '04–'09; Dir. N. H. Expt. Sta., '07–'09; Dean Coll. Agr., W. Va. Univ., '10—; Dir., W. Va. Expt. Sta., '12—.

1910. Robert Sidey Shaw, B. S. (Ontario Agr. Coll., '93); *East Lansing, Mich.;* Asst. Agr., Mont. Agr. Coll. and Expt. Sta., '97–'02; Prof. Agr., Mich. Agr. Coll., '02–'08; Dean Agr., do., and Dir. Expt. Sta., '08—.

1893. Thomas Shaw, *Buffalo, Mont.;* Prof. Agr., Ontario Agr. Coll., '88–'93; Prof. Anim. Husb., Minn. Coll. Agr., '93–'03; Ed. *Farmer*, '03–'08; Northwest Ed. Orange Judd Publications '08—.

1898. John Henry Shepperd, B. Agr. (Iowa State Coll., '91), M. S. A. (Univ. Wis., '93); *Agricultural College, N. Dak.;* Ed. Staff *Orange Judd Farmer*, '93; Prof. Agr., N. Dak. Agr. Coll., and

Agriculturist Expt. Sta., '93–'04; Dean and Vice Dir., do., '04—.

1909. John Harrison Skinner, B. S. (Purdue Univ., '97); *Lafayette, Ind.;* Asst. Agr., Ind. Expt. Sta., '99–'01; Instr. Anim. Husb., Univ. Ill., '01–'02; Assoc. Prof. Anim. Husb., Purdue Univ., '02–'06; Prof., do., '06; Dean Agr. Dept., Purdue Univ., '07—.

1907. Clinton DeWitt Smith, M. S. (Cornell Univ., '75); *Trumansburg, N. Y.;* Dir. Ark. Expt. Sta., '90; Dir. Minn. Sta., and Prof. Dairy Husb., Univ. Minn., '90–'93; Dir. Mich. Expt. Sta. and Prof. Agr., '93–'08; Dir. and Dean Spec. Course, Mich. Agr. Coll., '99–'08; Dir. Escola Agricola Practica, '08–'12.

1907. Howard Remus Smith, B. Sc. (Mich. Agr. Coll., '95); *University Farm, St. Paul, Minn.;* Teacher, Tilford Collegiate Acad. and Rock Island High School, '95–'09; Acting Prof. Agr., Univ. Mo., '00–'01; Asst. Prof. Anim. Husb., Univ. Nebr., '01; Assoc. Prof., do., '02; Prof., do., '03–'12; Anim. Husb., Univ. Minn., '12—.

1899. Harry Snyder, B. S. (Cornell Univ., '89); *1800 Summit Ave., Minneapolis, Minn.;* Asst. Chem., Cornell Univ. Expt. Sta., '90–'91; Asst. Instr. Qual. Anal., do., '89–'90; Prof. Agr. Chem., Univ. Minn., and Chem., Expt. Sta., '91–'09; Chem., Russell Miller Milling Co., '09—.

1909. Andrew McNairn Soule, B. S. (Univ. Toronto, '93), Sc. D. (honorary, Univ. Ga., 10); *Athens, Ga.;* Asst. Dir., Mo. Expt. Sta., '94; Asst. Prof. Agr. and Asst. Agriculturist, Tex. Agr. Coll. and Expt. Sta., '94–'99; Dir. Tenn. Expt. Sta. and Chairman Agr. Faculty, Univ. Tenn., '99–'04; Dean of Agr. and Dir. Expt. Sta., Va. Poly. Inst., '04–'07; Pres. Coll. Agr. Univ. Ga., '07—.

1903. William Jasper Spillman, B. S. (Univ. Mo., '86), M. S. (do., '89), Sc. D. (do., '10) *Washington, D. C.;* Prof. Sci., Mo. State Normal, '87–'89; Prof. Sci., Vincennes Univ., '89–'91; Prof. Sci., Ore. State Normal, '91–'94; Prof. Agr., State Coll. Wash., '94–'01; Agrostologist, U. S. Dept. Agr., '01–'04; Agriculturist in charge Farm Management, do., '04—.

1911. Frank Lincoln Stevens, B. L. (Hobart, '91), B. S. (Rutgers Coll., '93), M. S. (do., '97); Ph. D. (Univ. Chicago, '00); *Urbana, Ill.;* Teacher of Sci., Racine Coll., '93–'94; do., Columbus, O., High School, 94–'97; Instr. in Biol., N. C. Agr. Coll., '00–'02; Prof. Bot. and Veg. Path., do., '03–'11; Biol., N. C. Expt. Sta., '03–'11; Dean, P. R. Coll. Agr., '12–'14; Prof. Plant Path., Univ., Ill., '14—.

1908. William Alton Taylor, B. S. (Mich. Agr. Coll., '88), D Sc. (do., '13); *Washington, D. C.;* Asst. Pomol., U. S. Dept. Agr., '91–'01; Pomol. in charge Field Investigations, '01–'10; Asst. Chief, Bur. Plant Indus., '11–'13; Chief, do., '13—.

1911. Roscoe Wilfred Thatcher, B. Sc. (Univ. Nebr., '98), M. A. (do., '01); *University Farm, St. Paul, Minn.;* Asst. Chem., Nebr. Expt. Sta., '99–'01; Asst. Chem., Wash. Expt. Sta., '01–'03; Chem., do., '03–'12; Asst. Prof. Chem., State Coll. Wash., '04–'06; Assoc. Prof., do., '06–'10; Prof. Agr. Chem. and Head of Dept. Agr., do., '10-'13; Dir. Wash. Expt. Sta., '07–'13; Prof. Agr. Chem. and Agr. Chem., Univ. Minn. and Expt. Sta., '13—.

1907. Charles Embree Thorne, M. Agr. (Ohio State Univ., '90); *Wooster, Ohio;* Dir. Ohio Expt. Sta., '87—.

1910. Edward Gaige Titus, B. S. (Col. Agr. Coll., '99); M. S. (do., '01), D. Sc. (Harvard, '11); *Logan, Utah;* Asst. Dept. Zool. and Ento., Col. Agr. Coll., '00–'01; Field Asst. State Ento., Ill., '01–'03; Spec. Agt., Bur. Ento., U. S. Dept. Agr., '03–'07; Prof. Zool. and Ento., Utah Agr. Coll. and Ento., Expt. Sta., '07—.

1901 Charles Orrin Townsend, B. S. (Univ. Mich., '88); M. S. (do., '91), Ph. D., (Leipsic, '97); *Garden City, Kans.;* Prof. St. Johns Coll., Md.; '88–'91; Prof. Sci., Wesleyan Coll., Ga., '91–'95; Instr. Bot. Barnard Coll., '98; Prof. Bot., Md. Agr. Coll. and State Plant Path. Md., '98–'01; Path. Bur. Plant Indus., U. S. Dept. Agr., '01–'10; do., '12—; Consulting Agr., U. S. Sugar and Land Co., '10–'12.

1881. Samuel Mills Tracy, B. A. (Mich. Agr. Coll., '68), M. S. (do., '76); *Biloxi, Miss.;* Asst. Prof. Agr., Mo. State Univ., '77–'80; Prof. Bot. and Hort., do., '80–'87; Dir. Miss. Expt. Sta., '87–'97; Spec. Agt. U. S. Dept. Agr., '97—.

1908. William W. Tracy, Sr., B. S. (Mich. Agr. Coll., '67), M. S. (do., '70), D. Sc. (honorary, do., '07); *Washington, D. C.;* Prof. Hort., Mich. Agr. Col., '70–'72; Supt. of Testing Gardens, U. S. Dept. Agr., '02—.

1894. William Trelease, B. S. (Cornell, '80), D. Sc. (Harvard, '84), LL. D. (Wis., '02; Mo., '03; Wash. Univ., '07); *Urbana, Ill.;* Prof. Bot., Univ. Wis., '83–'85; Engelmann Prof. Bot. and Dir. Shaw School Bot., Wash. Univ., '85—; Dir. Mo. Bot. Gard., '89–'12; Research Work, '12–'13; Prof. Bot., Univ. Ill., '13—.

1913. Perry Fox Trowbridge, B. Pd. (Mich. Norm. Coll., '92), Ph. B. (Univ., Mich., '92), A. M. (do., '05), Ph. D. (Univ. Ill., '06), M. Pd. (Mich. Norm. Coll., '11); *Columbia, Mo.;* Instr. Chem., Univ. Mich., '94–'02; Sugar Chem., do., '02–'05; Research Asst. and Instr. in Chem., Univ. Ill., '05–'07; Agr. Chem. and Assoc. Chem., Univ. Mo. and Expt. Sta., '07–'08; Prof. and Chem., do., '08—.

1907. Alfred Charles True, B. A. (Wesleyan Univ., '73), M. A. (do., '76), Ph. D. (Erskine Coll., S. C., '86); D. Sc. (Wesleyan Univ., '06); *Washington. D. C.;* Prin. High School, Essex, N. Y., '73–'75; Instr. State Normal School, Westfield, Mass.,

'75–'82; Grad. Stud., Harvard Univ., '82–'84; Instr., Wesleyan Univ., '84–'88; Ed., U. S. Office Ext. Stas., '88–'91; Asst. Dir., do., '91–'93; Dir., do., '93—.

1908. ALFRED VIVIAN, Ph. G. (Univ. Wis., '94); *Columbus, Ohio;* Instr. Phar., Univ. Wis., '94–'95; Asst. Agr. Chem., do., '95–'97; Instr., do., and Asst. Chem., Expt. Sta., '97–'02; Assoc. Prof. Agr. Chem., Ohio State Univ., '02–'05; Prof. Agr. Chem., do., '05—.

1912. JOHN FRANCIS VOORHEES, B. S. A. (Univ. Tenn., '09), M. S. A. (do., '11), *Knoxville, Tenn.;* Asst. Observ., U. S. Weather Bur., New Orleans, La. '01; do., Knoxville, Tenn., '02–'05; Observ. in charge Knoxville Sta., '06—; Instr. in Met. and Consult. Met., Univ. Tenn. and Expt. Sta., '09—.

1893. HENRY JACKSON WATERS, B. Agr. (Univ. Mo. '86); *Manhattan, Kans.;* Asst. Agr., Mo. Expt. Sta., '87–'91; Prof. Agr., Pa. State Coll., '92–'95; Dean Coll. Agr. and Dir. Expt. Sta., Univ. Mo., '96–'09; Pres., Kans. State Agr. Coll., '09—.

1910. HERBERT JOHN WEBBER, B. Sc. Univ. Nebr., '89); M. A. (do., '90), Ph. D. (Wash. Univ., St. Louis, '00); *Riverside, Cal.;* Asst. in Bot., Univ Nebr., '89–'90; Asst., Shaw School of Bot., '90–'92; Physiol., U. S. Dept. Agr., '92–'97; in charge Plant Breeding Lab., do., '97–'07; Prof. Expt. Plant Breeding, Cornell Univ., '07–'12; Dir., Citrus Expt. Sta., and Dean, Grad. School Trop. Agr., Univ. Cal., '13—.

1889. CLARENCE MOORE WEED, B. S. (Mich. Agr. Coll., '83), M. S. (do., '84), D. Sc. (Ohio State Univ., '89); *Lowell, Mass.;* Asst. State Ento., Ill., '86–'88; Ento., Ohio Expt. Sta., '88–'91; Prof. Zool. and Ento., N. H. Coll., and Ento., Expt. Sta., '91–'04; Nature Study Work, State Normal School, Lowell, Mass., '04—.

1896. JULIUS BUELL WEEMS, B. Sc. (Md. Agr. Coll., '88), Ph. D. (Clark Univ., '94); *South Boston, Va.;* Instr. Chem. and Math., Md. Agr. Coll., '88–'89; Con. Chem., do., '91–'92; Prof. Agr. Chem and Chem. Expt. Sta., Iowa State Coll., '95–'04; Industrial Chem., '04—.

1904. HOMER JAY WHEELER, B. Sc. (Mass. Agr. Coll. and Boston Univ., '83), Ph. D. (Univ. Göttingen, '89), D. Sc. (Brown, '11); *92 State St., Boston, Mass.;* Asst. Chem., Mass. Expt. Sta., '83–'87; Chem., R. I. Expt. Sta., '89–'08; Prof. Geol., R. I. Coll., '89–'12; Prof. Agr. Chem., do., '03–'10; Acting Pres., do., '02–'03; Dir. Expt. Sta., do., '01–'12, Agron,. do., '05–'12; Expert, Amer. Agr. Chem. Co., '12—.

1889. MILTON WHITNEY, *Washington, D. C.;* Asst. Chem., Conn. Expt. Sta., '83; Supt. Expt. Farm, N. C. Expt. Sta., '86–'88; Prof. Agr., S. C. Coll., and Vice Dir. Expt. Sta., '88–'91; Soil Physicist, Md. Expt. Sta., '91–'94; Prof. Soil Physics, Md. Agr. Coll., '94–'01; Chief Bur. Soils, U. S. Dept. Agr., '94—.

1898. JOHN CHARLES WHITTEN, B. S. (S. Dak. Agr. Coll., '91), M. S.

(do., '99), Ph. D. (Univ. Halle, '02); *Columbia, Mo.;* Instr. in Hort. and Hort. Expt. Sta., S. Dak. Agr. Coll., '92; Asst. in Hort., Mo. Bot. Gard., '93–'94; Prof. Hort. and Hort. Expt. Sta., Univ. Mo., '94—.

1911. John Andreas Widtsoe, B. S. (Harvard Univ., '94), Ph. D. (Univ. Göttingen, '99); *Logan, Utah;* Chem., Utah Expt. Sta., '94–'05; Prof. Chem., Utah Agr. Coll., '95–'05; Dir. Utah Expt. Sta., '00–'05; Dir. School of Agr., Brigham Young Univ., '05–'07; Pres., Utah Agr. Coll., '07—.

1908. Harvey Washington Wiley, A. B. (Hanover, '67), M. D. (Indiana Med. Coll., '71), B. S. (Harvard, '73), Ph. D. (Hanover, '76), LL. D. (do., '98); *Washington, D. C.;* Prof. Chem., Butler, '73–'74; Prof. Chem., Purdue Univ., '74–'83; State Chem., Ind., '81–'83; Chief, Div. Chem., U. S. D. A., '83–'01; Chief, Bur. Chem., do., '01–'12; Writer and Lecturer, '12—.

1912. Julius Terrass Willard, B. S. (Kans. Agr. Coll., '83), M. S. (do., '86), D. Sc. (do., '08); *Manhattan, Kans.;* Asst. in Chem., Kans. Agr. Coll., '83–'87; Asst. Prof. Chem., do., '90–'96; Assoc. Prof. Chem., do., '96–'97; Prof. Appl. Chem., do., '97–'01; Prof. Chem., do., '01— Dean, Div. Gen. Sci., do., '09—; Asst. Chem., Kans. Expt. Sta., '88–'97; Chem., do., '97—; Dir. do., '00–'06; Chem., Kans. Engin. Expt. Sta., '10—.

1912. Charles Burgess Williams, B. S. (N. C. Agr. Coll., '93), M. S. (do., '96); *West Raleigh, N. C.;* Asst. Chem., N. C. Dept. Agr., '93–'06; Agron., do., '06–'07; Dir. and Agron., N. C. Expt. Sta., '07–'12; Vice Dir. and Agron., do., '13—.

1908. Carlos Grant Williams, *Wooster, Ohio;* Agron., Ohio Expt. Sta., '03—.

1911. William Alphonso Withers, A. B. (Davidson Coll., '83), A. M. (do., '85); *West Raleigh, N. C.;* Asst. Chem., N. C. Expt. Sta., '84–'88; Prof. Chem., N. C. Agr. Coll., '89—; Statis. Agt., U. S. Dept. Agr., '95–'02; Acting Dir., N. C. Expt. Sta., '97–'99; Chem., do., '97—.

1909. Fritz Wilhelm Woll, B. S. (Royal Frederiks Univ., Christiania, '82), Ph. B. (do., '83), M. S. (Univ. Wis., '86), Ph. D. (do., '04); *Davis, Cal.;* Asst. Chem., Wis. Expt. Sta., '87–'97; Chem., do., '97–'13; Asst. Prof. Agr. Chem., Univ. Wis., '93–'04; Assoc. Prof., do., '04–'06; Prof., do., '06–'13; Prof. Anim. Nutr., Univ. Cal. and Expt. Sta., '13—.

1903. Albert Frederick Woods, B. Sc. (Univ. Nebr., '90), A. M. (do., '92), D. Agr. (do., '13); *University Farm, St. Paul, Minn.;* Asst. Bot., Univ. Nebr., '91–'94; Asst. Chief Div. Veg. Path., U. S. Dept. Agr., '94–'00; Chief, do., '01–'09; Asst. Chief, Bur. Plant Indus., do., '01–'09; Dean Coll. of Agr., Univ. Minn., and Dir. Expt. Sta., '10—.

1903. Charles Dayton Woods, B. S. (Wesleyan Univ., Conn., '80), D. Sc. (honorary, Univ. Me., '05); *Orono, Me.;* Asst., Chem.,

Wesleyan Univ., '80–'85; Instr. Sci., Wilbraham Acad., Mass., '83–'88; Chem., Conn. Storrs Expt. Sta., '88–'96; Vice Dir., do., '89–'96; Prof. Agr., Univ. Me., '86–'03; Dir. Maine Expt. Sta., '96—.

1911. BONNEY YOUNGBLOOD, B. S. (Tex. Agr Coll., '02), M. S. (do., '07); *College Station, Tex.;* Prin. and Instr. in Agr., Henderson, Tex., City Schools, '03–'05; Prin. and Instr. in Agr., Mineola, Tex., High School, '05–'06; Supt. City Schools and Instr. in Agr., Pauls Valley, Okla., '06–'07; Asst. Agr., Office of Farm Management, U. S. Dept. Agr., '07–'11; Dir., Tex. Expt. Sta., '11—.

1910. C. A. ZAVITZ, B. Sc. (Toronto Univ., '88); *Guelph, Canada;* Asst. Expt. Dept., Ontario Agr. Coll., '86–'93; Head of Expt. Dept., '93—; Prof. of Field Husbandry, Ontario Agr. Coll., '04—.

Deceased Members.

Robert Fairchild Kedzie,	Born	Dec. 9, 1852	Died	Feb. 13, 1882
Lauren Briggs Arnold,	"	Aug. 13, 1814	"	Mar. 7, 1888
George Hammel Cook,	"	Jan. 5, 1818	"	Sept. 22, 1889
Patrick Barry,	"	May 24, 1816	"	June 24, 1890
John J. Thomas,	"	Jan. 8, 1818	"	Feb. 22, 1895
Charles Valentine Riley,	"	Sept. 18, 1843	"	Sept. 14, 1895
Charles Lee Ingersoll,	"	Nov. 1, 1844	"	Dec. 15, 1895
Edward Louis Sturtevant,	"	Jan. 23, 1842	"	July 30, 1898
Sir John B. Lawes, *Hon Mem.*,	"	Dec. 28, 1814	"	Aug. 31, 1900
John Alvah Myers,	"	May 29, 1853	"	April 8, 1901
Sir Henry Gilbert, *Hon. Mem.*,	"	Aug. 1, 1817	"	Dec. 23, 1901
Robert Clark Kedzie,	"	Jan. 28, 1883	"	Nov. 27, 1902
Victor Hunt Lowe,	"	Sept. 23, 1869	"	Aug. 27, 1903
Henry English Alvord,	"	Mar. 11, 1844	"	Oct. 1, 1905
Robert Warington, *Hon. Mem.*,	"	Aug. 22, 1838	"	Mar. 20, 1907
Willis Grant Johnson,	"	July 4, 1866	"	Mar. 11, 1908
James Fletcher,	"	Mar. 28, 1852	"	Nov. 8, 1908
Samuel William Johnson,	"	July 3, 1830	"	July 21, 1909
William Henry Brewer,	"	Sept. 14, 1828	"	Nov. 2, 1910
Charles Anthony Goessmann,	"	June 13, 1827	"	Sept. 1, 1910
Samuel B. Green,	"	Sept. 15, 1859	"	July 11, 1910
Welton M. Munson,	"	April 8, 1866	"	Sept. 9, 1910
Edward Burnett Voorhees,	"	June 22, 1856	"	June 6, 1911
Franklin Hiram King,	"	June 8, 1848	"	Aug. 4, 1911
Oskar Kellner, *Hon. Mem.*,	"	May 13, 1851	"	Sept. 22, 1911
John Bernhardt Smith,	"	Nov. 21, 1858	"	Mar. 12, 1912
Melville Amasa Scovell,	"	Feb. 26, 1855	"	Aug 15, 1912

PROCEEDINGS

OF THE

THIRTY-FIFTH ANNUAL MEETING

OF THE

Society for the Promotion of Agricultural Science

HELD AT

WASHINGTON, D. C.

November 10, 1914

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Washington

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OFFICERS OF THE SOCIETY FOR 1915.

President . . . . H. J. WATERS, Manhattan, Kansas.

Vice-President . . . . CHAS. E. THORNE, Wooster, Ohio.

Secretary-Treasurer . . L. A. CLINTON, U. S. Department of Agriculture, Washington, D. C.

Custodian . . . . W. D. HURD, Amherst, Mass.

Executive Committee . . . . DAVID FAIRCHILD.
H. P. ARMSBY.
W. H. JORDAN.

THIRTY-FIFTH ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF AGRICULTURAL SCIENCE.

The regular printed program was carried out, all the papers being presented. Invitation was extended to the American Society of Agronomy, the American Society of Animal Production, and the American Farm Management Association, in session at the same time as the Society, to attend the meetings. Many men from these other societies were present. In the evening a joint session was held with the American Society of Agronomy, Dr. W. J. Beal presiding. This session was confined to the addresses of the presidents of the two societies—President H. J. Waters, of the Society for the Promotion of Agricultural Science, on Corn as a Feed, and Prof. C. V. Piper, president of the American Society of Agronomy, on Fundamental Principles in Agronomy.

BUSINESS MEETING.

At a short business meeting at the conclusion of the afternoon session the reports of the Secretary-Treasurer and of the Assistant Custodian were presented.

The decision of the Executive Committee having done away with the former method of electing officers by ballot and no procedure having been suggested, it was moved that a nominating committee be appointed for the present meeting, and that in future a nominating committee of three be named by nomination from the floor and elected by the general assembly, in case more than three are nominated, in time to give opportunity for proper consideration of proposed officers. This procedure was adopted. A nominating committee, consisting of Prof. C. P. Gillette, Dr. G. S. Fraps, and Dr. W. J. Beal, made the following report, which was adopted at a brief meeting at the conclusion of the evening session: For President, H. J. Waters, of Kansas; Vice-President, Charles E. Thorne, of Ohio; Secretary-Treasurer, Prof. L. A. Clinton, U. S. Depart-

ment of Agriculture; additional member of Executive Committee, David G. Fairchild; Custodian, W. D. Hurd, Amherst, Mass. Dr. Beal resigned from the position of Custodian, and on his suggestion the post of Assistant Custodian was abolished.

The proposal to hold a series of joint meetings representing the various agricultural societies, in California during August, 1915, was reported and the Chairman of the Executive Committee and the Secretary of the Society were designated to represent the Society on the Committee of Arrangements.

The date and place of the next meeting of the Society were discussed, and it was voted to leave these matters to the Executive Committee.

The auditing committee, consisting of F. W. Rane, J. C. Kendall, and J. F. Duggar, reported that they had examined the accounts of the Secretary-Treasurer and the Custodian, and found them correct.

The following list of new members was elected: Dr. E. D. Ball, Director of Utah Experiment Station; Dean A. B. Cordley, Director of the Oregon Experiment Station; Prof. H. E. Van Norman, Dean of the University Farm School, Davis, California; Dean R. L. Watts, Director Pennsylvania Experiment Station, and Dr. I. D. Cardiff, Director of the Washington Experiment Station.

THE REQUIREMENTS OF THE GROWING ANIMAL.

PRESIDENT'S ADDRESS.

By H. J. Waters,
Kansas Agricultural College.

Perhaps I should offer an apology for presenting a technical discussion as the President's annual address. The matter to which I shall invite your attention, however, is of such universal application, and is so vitally related to the development of a strong race of people, that I trust it may have a general interest. Indeed, I can conceive of no more fundamental study than that which seeks to provide a means for the well-balanced development of the young of the farm and of the home.

It is well known that all of the cereals, our principal source of nourishment, have marked deficiencies as a means of supporting animal growth, although as a source of energy they have a very high value. Just what must be added to these grains to supply the deficiencies is yet in dispute. All of the work done along this line indicates clearly that the grains alone will not supply all of the materials required for the normal development of the young.

Weanling pigs, for example, when required to subsist entirely upon corn, usually soon cease to gain in weight and become unthrifty. Occasionally one will die, apparently of starvation. Similar pigs fed on corn supplemented by materials relatively rich in protein and ash, such as skim milk, wheat middlings, meat meal, blood meal, or tankage, continue to gain and remain thrifty. It is a common farm practice in the Corn Belt to give pigs no other grain than corn, and, while they make a slow and usually an unprofitable gain, yet they remain reasonably thrifty. Farm pigs, however, usually have the run of pastures or of considerable range and are usually able to supplement their corn diet with numerous insects and with the roots, stems, leaves and seeds of a great variety of plants. They also consume considerable quantities of earth and other mineral matter.

The question arises, what is supplied in the milk, middlings, tankage or pasturage, which enables the pigs to make growth with corn as the sole grain? Or, putting the question more direct, in what respect does corn fail to supply the nutrients required for the normal growth of young pigs? Is it the ash material which is lacking in corn that the pigs find for themselves when allowed access to the soil and to such plants as clover, alfalfa, rape, blue grass, or when given milk, middlings, or tankage? Or, is it a deficiency either in the amount or quantity of protein in corn which is supplied by these materials? Is it possible that both ash and protein of the proper kind are deficient in corn?

To seek an answer to these questions, experiments were begun at the Kansas Experiment Station in 1909, and have been continued to the present.[1]

Four trials of from six to twelve months each have been completed, and a fifth trial is complete with the exception of the chemical analysis. More than 150 pigs have been used in these experiments. To determine the character and amount of the materials stored in the body during the feeding periods in all the experiments except the first one, two animals were slaughtered and the amounts of water, fat, protein and ash were determined at the beginning of the experiment, and one animal from each group was slaughtered and analyzed at the end of the period. By this means the amount of water, fat, protein and ash stored in the body of the pigs fed in different ways could be approximated.

Each pig was fed separately and an individual feed record was kept. In two seasons digestion trials were made

[1] Dr. J. T. Willard, Chemist; W. A. Cochel, Professor of Animal Husbandry; Turner R. H. Wright, formerly assistant Professor of Animal Husbandry, now Livestock Editor of the *Mail and Breeze;* C. M. Vestal, Assistant Professor of Animal Husbandry; John W. Calvin, formerly Assistant Chemist, now Associate in Animal Nutrition, University of Nebraska; C. O. Swanson, Associate in Chemistry; Dr. Albert Hogan, Assistant in Physiological Chemistry, have been associated with the speaker in this work.

with representative animals of each lot to enable us to estimate more accurately than would otherwise be possible, the amount of material fed that was digested. All trials were made in triplicate; that is, three pigs were used in each lot. In choosing the pigs for the experiment, one pig from a litter was put in each lot. Thus, if five lots were to be compared we chose from the 600 or more pigs farrowed on the station farms each year, three litters containing five male pigs, each of uniform size and development, one of which was put in each lot.

The trials were all begun early in July with pigs that had been farrowed in March or April. Usually this was as soon as the pigs were weaned, and when they weighed from 35 to 50 pounds each.

RATIONS FED.

An attempt was made to supplement corn with ash on the one hand, and with protein of a known value or purity on the other, and to compare the results with those obtained from the use of an exclusive corn diet.

Corn Alone.—One lot in each trial was fed on corn alone, ground reasonably fine.

Corn and Ash.—One lot was fed on a ration of ground corn and ash.

In the first trial the ash consisted of bone ash and in the other trials it consisted of ash prepared somewhat after the formula of Osborne and Mendel, as follows:

Tertiary calcium phosphate, 10 parts;
Secondary potassium phosphate, 37 parts;
Sodium chloride, 20 parts;
Sodium citrate, 15 parts;
Calcium lactate, 8 parts, and
Ferric citrate, 2 parts;
Total, 92 parts.

These materials were ground and mixed intimately with an equal weight of calcium carbonate. This mixture was

fed in an amount equal to two percent. of the corn fed, thoroughly mixed with the ground corn.

In one trial an additional lot of pigs was fed in which the corn was supplemented by the ash of cow's milk.

In trials three and four one lot each was fed on corn supplemented with protein-free skim milk, or skim milk from which the protein and a small part of the ash had been removed. As a rule about 70 percent. of the total ash of the milk, more than 90 percent. of the calcium, and about 68 percent. of the phosphorus remained in the milk, after the protein was extracted. The protein-free skim milk obtained from three pounds of skim milk was fed, combined with one pound of corn. It was our purpose in feeding this ration to supplement the corn with an organic ash, balanced as nearly as possible as it is balanced in nature, for it is supposed that the ash remaining in the milk after the proteins were extracted by precipitation with the acetic acid is in an organic form.

A ration of corn and skim milk was not used in the trials because everyone acquainted with farm practice is familiar with the satisfactory results that are obtained when this ration is used. In short, a quantity of skimmed cow's milk was divided into two groups, one containing essentially all the proteins and a very small part of the ash and the other group containing most of the ash, all the sugar water which the original milk contained. To one lot of pigs the proteins obtained from three pounds of skim milk was fed with each pound of corn. To another lot, what was left of three pounds of milk after the proteins were removed was combined with each pound of corn.

If it is the ash in skim milk that is so helpful in a ration of corn and skim milk, it would manifest itself when corn and protein-free milk is fed.

If, on the other hand, it is the protein in the skim milk that is needed, it would become manifest when the proteins of the milk are fed without the ash. If both ash and the proteins are necessary and neither without the other would properly balance corn, the effect of adding one to corn without the other would be nil.

Corn and Protein.—One lot in each trial was fed on corn and a complete protein that was as nearly free from ash as possible. In the first trial the supplementary feed consisted of black albumen made from blood. This material, however, was found to supply too much ash for the purpose of the experiment, therefore, in subsequent trials the protein was obtained from cow's milk.

In the first trial with protein-free milk all the proteins of the milk were extracted together. In each of the subsequent trials the corn of one lot of pigs was supplemented with casein and another with milk albumen.

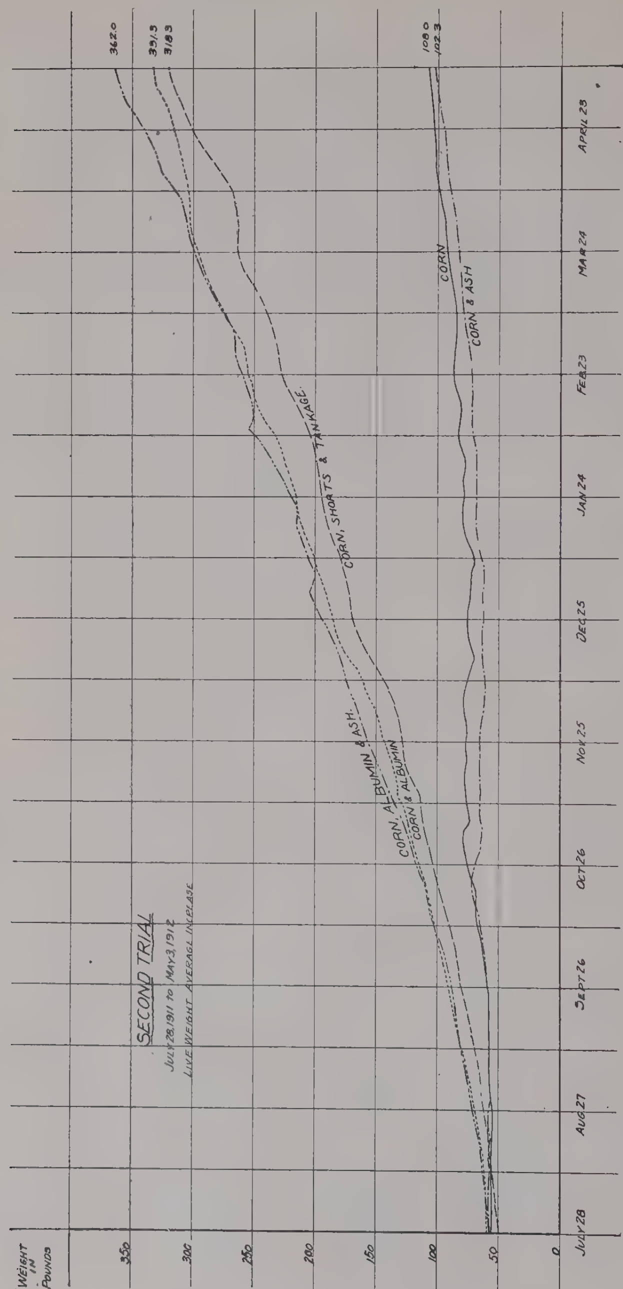
The milk albumens were obtained by warming skimmed milk to about 35 degrees C. with steam and precipitated with 10 percent. acetic acid. The casein was filtered and washed twice with cold distilled water. In the filtrate from the casein the albumen was precipitated by boiling a few minutes with steam. The albumen was allowed to settle off for a few hours and after siphoning the supernatant liquid was drained on linen and washed once with boiling distilled water.

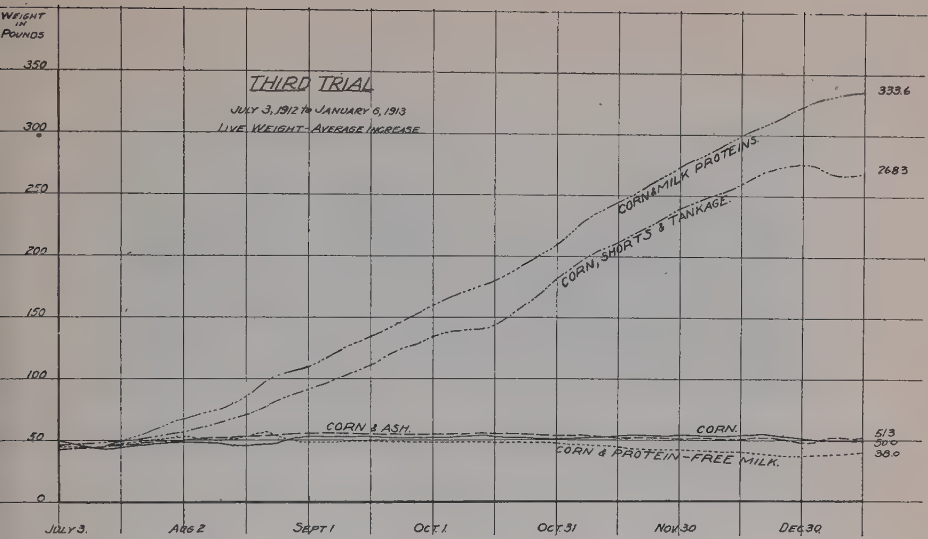
GAIN IN LIVE WEIGHT.

The accompanying graphs and illustrations show the effect of the different rations upon the weight and form of the animals to which they were fed.

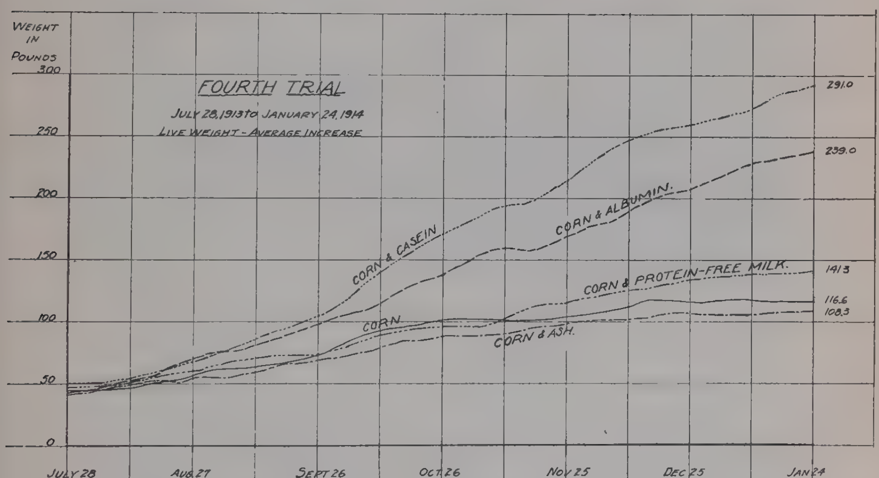
When Ash is Added to Corn.—All of our attempts to increase the efficiency of corn by adding ash alone have shown negative results. When bone ash was added, no better gains were obtained than when corn alone was fed. When a prepared ash, based upon the formula found satisfactory by Osborne and Mendel, but in which magnesium citrate was not added, because corn is relatively rich in this mineral, and in which calcium was greatly increased by the addition of calcium carbonate, no beneficial results were obtained.

In three trials in which protein-free skim milk containing approximately 70 percent. of the total ash of the milk presumably in an organic form was fed, the results were

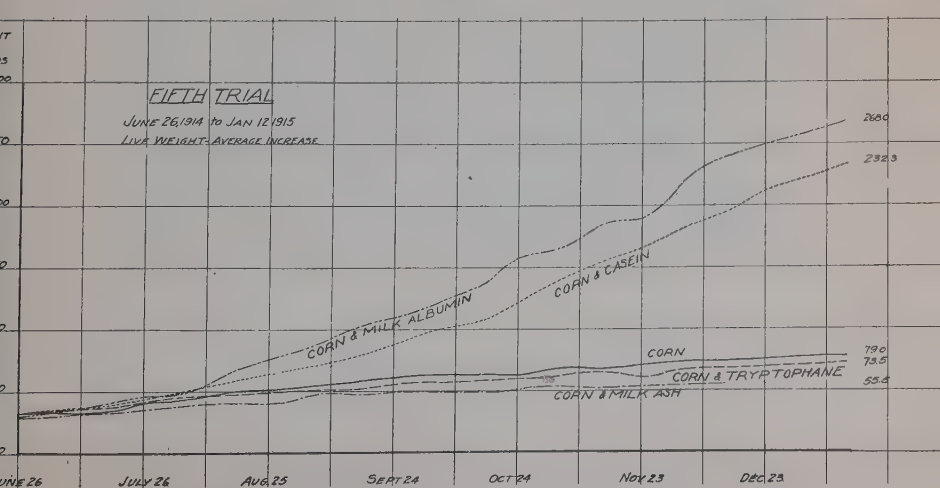

SECOND TRIAL
JULY 28, 1911 TO MAY 3, 1912
LIVE WEIGHT AVERAGE INCREASE
WEIGHT IN POUNDS
0
50
100
150
200
250
300
350
JULY 28
AUG 27
SEPT 26
OCT 26
NOV 25
DEC 25
JAN 24
FEB 23
MAR 24
APRIL 23
362.0
331.3
318.3
108.0
102.3
CORN
CORN & ASH
CORN, SHORTS & TANKAGE.
CORN, ALBUMIN & ASH.
CORN & ALBUMIN



WEIGHT IN POUNDS
THIRD TRIAL
JULY 3, 1912 to JANUARY 6, 1913
LIVE WEIGHT - AVERAGE INCREASE
CORN & MILK PROTEINS.
CORN, SHORTS & TANKAGE.
CORN & ASH.
CORN.
CORN & PROTEIN-FREE MILK.
333.6
268.3
51.3
50.0
38.0
350
300
250
200
150
100
50
0
JULY 3.
AUG 2
SEPT 1
OCT 1.
OCT 31
NOV 30
DEC 30



WEIGHT IN POUNDS
FOURTH TRIAL
JULY 28, 1913 to JANUARY 24, 1914
LIVE WEIGHT - AVERAGE INCREASE
CORN & CASEIN
CORN & ALBUMIN.
CORN & PROTEIN-FREE MILK.
CORN.
CORN & ASH.
291.0
239.0
141.3
116.6
108.3
300
250
200
150
100
50
0
JULY 28
AUG 27
SEPT 26
OCT 26
NOV 25
DEC 25
JAN 24



FIFTH TRIAL
JUNE 26, 1914 to JAN 12 1915
LIVE WEIGHT - AVERAGE INCREASE
CORN & MILK ALBUMIN
CORN & CASEIN
CORN
CORN & TRYPTOPHANE
CORN & MILK ASH
268.0
232.3
79.0
73.5
55.5
JUNE 26
JULY 26
AUG 25
SEPT 24
OCT 24
NOV 23
DEC 23

FIG. I.—CORN MEAL.

Weight, July 3, 1912, 57 lbs. Weight, January 6, 1913, 64 lbs.

Gain in six months, 7 lbs.

FIG. II.—CORN AND ASH.

Weight, July 3, 1912, 51 lbs. Weight, January 6, 1913, 50 lbs.

Loss in six months, 1 lb.

FIG. III.—CORN AND PROTEIN-FREE MILK.

Weight, July 3, 1912, 50 lbs. Weight, January 6, 1913, 27 lbs.

Loss in six months, 23 lbs.

FIG. IV.—CORN AND MILK PROTEINS.

Weight, July 28, 1913, 47 lbs. Weight, January 24, 1914, 310 lbs.

Gain in six months, 263 lbs.

FIG. V.—CORN AND MILK ALBUMIN.

Weight, July 28, 1913, 42 lbs. Weight, January 24, 1914, 245 lbs.

Gain in six months, 203 lbs.

FIG. VI.—CARCASSES OF LITTER MATES.

A.—Corn and Milk Proteins. Weight of Carcass, 280 lbs.

B.—Corn and Protein-free Skim Milk. Weight of Carcass, 23 lbs.

negative. In one trial with the ash of the milk, the results agreed with those of the previous trials and no appreciable increase in the gain in live weight was obtained over that obtained from feeding corn alone.

Apparently we have not used ash in the proper form or in the proper proportion, or else the conclusion is inevitable that some other material besides ash must be supplied to remedy the deficiencies of corn for the growing animal.

When Protein is Added to Corn.—It is not easy to provide a complete protein that is ash-free and that is also palatable and cheap enough to be used in an experiment of the magnitude of ours. The molecule of many proteins contains phosphorus. Moreover, in all the processes of separation of animal protein that we have followed, some of the ash, not a part of the protein molecule, has gone down with the protein. Thus, for example, in trial II, when albumen obtained from blood was fed, there was supplied from this source about 30 percent. of the ash contained in the ration, a greater amount of mineral matter than the pigs receiving this ration stored in their bodies.

Likewise, when the total proteins of milk were fed, there was added with these proteins more than half as much mineral matter as was supplied by the corn consumed and more than was stored in the bodies of the pigs receiving this ration. When casein was the form of protein, there was supplied with the proteins a much smaller amount of ash than by the other rations, yet enough to have furnished all the minerals stored in the bodies of the pigs fed on this ration. It was only when milk albumen, a non-phospho-protein, was fed that we were able to approximate an ash-free protein. In this ration, consisting of 721.46 lbs. of corn and 67.42 lbs. of milk albumen for each pig in the six-month trial, out of a total of 15.47 lbs. of mineral supplied, only .83 lbs. came from the protein. It would seem, therefore, that the supplying of this amount of ash with the protein in the course of a six-months feeding trial might be disregarded.

As a study of the graphs will show, there was a striking

increase in weight of all lots given protein in addition to that contained in corn.

In trial II, for example, the average weight of the pigs fed on corn and blood albumen was 330 pounds as compared with 108 pounds for the pigs fed corn alone, and 102 pounds for the pigs fed corn and ash.

In trial III, the pigs receiving corn and milk protein, weighed an average of 333 pounds at the close of the experiment, as compared with 51 pounds each for litter mates fed on corn alone and 50 pounds for those fed corn and ash, and 38 pounds each for the pigs fed corn and protein-free skim milk.

In trial IV, the corn and casein lot weighed an average of 291 pounds, the corn and albumen lot 239 pounds, the corn lot 116 pounds, the corn and ash lot, 108 pounds, and the corn and protein-free skim milk lot 141 pounds.

In trial V, the pigs fed on corn and milk albumen weighed, on an average, 268 pounds at the end of the trial, those on corn and casein 232 pounds; those on corn 79 pounds, and those on corn and milk ash 55 pounds.

Obviously, there was something in the protein supplements used which supplied the deficiencies of corn, at least to a considerable degree.

Inasmuch, however, as we did not approximate an ash-free protein in but one trial in which the records are complete, it cannot be positively concluded that this striking increase in the efficiency of the ration shown when the protein supplement was used was due to the protein alone. It is possible that to secure these results it was necessary to supplement the corn with mineral matter as well as with protein.

The only evidence to the contrary is furnished by the results of the use of milk albumen in trial four. In that case as has already been explained, only .83 pounds of ash was supplied in the protein for each pig in the six months feeding trial. Unfortunately, a strict comparison cannot be made between the results from feeding casein, which contained considerable ash, and the lot fed on milk albumen which contained very little ash because, for the

purpose of other comparisons, the casein and albumen from the same amount of milk was fed to each lot instead of the same amount of protein in each case. Milk contains only about half as much albumen as casein, therefore the amount of protein fed to each pig as albumen was 70.22 pounds and 132.92 pounds as casein. The amount of carbohydrates fed was not widely different for the two lots, being 507 pounds for the albumen lot and 577 pounds for the casein lot. In the fat the amounts fed were 18.12 and 21.62 lbs. respectively. The nutritive ratio was 1:7.75 in the albumen lot and 1:4.70 in the casein lot.

A study of the results does not show a striking difference in the amount of material stored in the body.

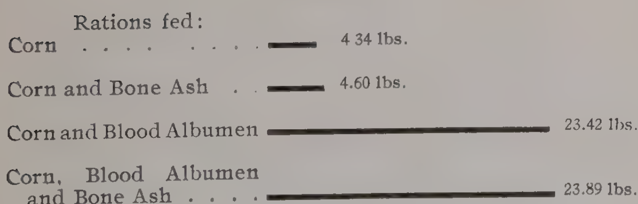
In the fifth trial, the results of which are not fully calculated, in which equal amounts of protein in the form of casein and albumen were fed, a greater gain in live weight from the use of albumen than from casein is shown.

MATERIAL STORED IN THE BODY.

No less striking are the results as measured by the amounts of protein, ash and fat stored in the body under the different systems of nourishment compared. The following tables present a summary of the results computed on the basis of the analysis of two check pigs at the beginning of the trial and of a representative animal from each lot at the close of the trial.

PROTEIN STORED.

Trial No. 2.



Trial No. 3.

Corn . . . . Loss.

Corn and Prepared Ash .68 lbs.

Corn and Protein-free Skim Milk . . . . .40 lbs.

Corn Milk Proteins . . . 28.08 lbs.

Trial No. 4.

Corn . . . . 5.32 lbs.

Corn and Prepared Ash . 5.71 lbs.

Corn and Protein-free Skim Milk . . . . . 6.00 lbs.

Corn and Casein . . . . 18.47 lbs.

Corn and Milk Albumen 18.09 lbs,

Corn daily, Milk Proteins every seventh day . . . . 15.94 lbs.

Scale $\frac{1}{16}''$ to 1 lb.

FAT STORED.

Trial No. 2.

Rations fed:

Corn . . . . 40.66 lbs.

Corn and Bone Ash . . 34.30 lbs.

Corn and Blood Albumen 178.44 lbs.

Corn and Blood Albumen and Bone Ash . . . 182.96 lbs.

Trial No. 3.

Corn . . . . 2.11 lbs.

Corn and Prepared Ash . Loss.

Corn and Protein-free Skim Milk . . . . Loss.

Corn and Milk Proteins 155.33 lbs.

Trial No. 4.

Corn	40.77 lbs.
Corn and Prepared Ash	30.91 lbs.
Corn and Protein-free Skim Milk . .	56.66 lbs.
Corn and Casein	119.63 lbs.
Corn and Milk Albumen	105.84 lbs.
Corn daily, Milk Proteins every seventh day	103.03 lbs.

Scale $\frac{1}{64}''$ 1 lb.

ASH STORED.

Trial No. 2.

Rations fed:

Corn	.73 lbs.
Corn and Bone Ash . .	1.04 lbs.
Corn and Blood Albumen	3.11 lbs.
Corn, Blood Albumen and Bone Ash . . .	4.65 lbs.

Trial No. 3.

Corn	Loss.
Corn and Prepared Ash .	.55 lbs.
Corn and Protein-free Skim Milk	Loss.
Corn and Milk Proteins	3.93 lbs.

Trial No. 4.

Corn	.44 lbs.
Corn and Prepared Ash	.58 lbs.
Corn and Protein-free Skim Milk	.60 lbs.
Corn and Casein	2.76 lbs.
Corn and Milk Albumen	1.67 lbs.
Corn daily, Milk Protein every seventh day	1.67 lbs.

Scale ½″ to 1 lb.

RELATION OF THE AMOUNT OF ASH IN THE RATION AND THE AMOUNT STORED.

There does not seem to be a constant relation between the ash content of the ration and the storage of ash in the body. This is brought out in the following table :

TABLE II.—DISTRIBUTION OF ASH IN FEED CONSUMED.

Experiment No. 2.

	From Corn *lbs.*	From Bone Ash *lbs.*	From Blood Albumen *lbs.*		Total Consumed *lbs.*	Total Ash Stored in Body *lbs.*
Lot 1 . . .	6.07				6.07	.73
Lot 2 . . .	5.77	10.07			15.84	1.04
Lot 3 . . .	16.42		5.08		21.50	3.11
Lot 4 . . .	17.75	40.54	5.41		63.70	4.65

Experiment No. 3.

	From Corn *lbs.*	From Prepared Ash *lbs.*	From Protein-free Skim *lbs.*	From Milk Proteins *lbs.*	Total Consumed *lbs.*	Total Ash Stored in Body *lbs.*
Lot 6 . . .	2.92				2.92	Loss
Lot 7 . . .	2.50	3.36			5.86	.55
Lot 8 . . .	1.73		2.19		3.92	Loss
Lot 9 . . .	13.71			1.19	19.90	3.93

Experiment No. 4.

	From Corn *lbs.*	From Prepared Ash *lbs.*	From Protein-free Skim Milk *lbs.*	From Casein *lbs.*	From Milk Albumen *lbs.*	Total Consumed *lbs.*	Total Ash Stored in Body *lbs.*
Lot 13 . . .	8.33					8.33	.44
Lot 14 . . .	7.21	7.10				14.31	.58
Lot 15 . . .	8.29		7.02			15.31	.60
Lot 16 . . .	19.79			3.12		19.91	2.76
Lot 17 . . .	14.64				.83	15.47	1.67

The ash storage was very small—almost negligible—when no protein except that contained in the corn was supplied. When corn was supplemented by protein the ash storage was greatly increased, even though the protein itself supplied only a part of this protein, if we may rely upon the results of lot 17 in the fourth trial.

In every instance, when an animal protein was added to corn, the increase in the rate of gain in live weight over those having corn alone or ash and corn is very striking in every trial.

THE EFFECT OF THE PROTEIN UPON THE AMOUNT OF FOOD CONSUMED.

In all the trials each animal was given as much feed as it would eat twice a day. In every case the amount of feed consumed by the pigs fed corn alone, corn and ash, or corn and protein-free milk was small. In some cases it was less than was required to sustain life, and death from starvation ensued. In most other instances, it was little more than the amount required for maintenance and, as already shown, little gain in live weight or of body substance was made. The animals seemed to be hungry and apparently were not satisfied after they had eaten their meal. They would eat paper, wood, and almost any other unpalatable substance that might come within their reach.

When the protein supplement was added to the ration, there was a striking increase in the amount of feed consumed, and in no instance was there a loss of appetite or a failure of the animal to consume an amount largely in excess of the maintenance requirements. There was no evidence of uneasiness or dissatisfaction and no disposition to eat foreign material.

With other but similar pigs a number of attempts were made to stimulate the appetite, by sprouting the grain, or by adding such condiments as butter, acetic acid and lactic acid. For a few days the appetite of the animal would respond slightly, but the response was in each instance temporary.

THE AMOUNT OF PROTEIN SUPPLIED BY CORN.

We have been in the habit of thinking of corn as containing approximately 14.50 percent. of crude protein, or something like nine or ten percent. of digestible protein. Recent studies of the individual proteins of corn and their nutritive value have shown that only a part of the protein from corn is capable of supporting the growth process.

THE PROTEINS OF CORN.

	Percent. of corn	Percent. of protein
Globulins + albumins + "proteoses"......	3.19	21.9
Zein	6.00	41.4
Maize glutelin	4.50	30.8
Insoluble in alkali	0.88	5.9
	14.57	100.0

THE NUTRITIVE RATIO OF CORN.

It is now well established, for example, that the zein of corn is incomplete and therefore incapable of building new tissue as growth or for the purposes of repair. For the purposes, therefore, of sustaining growth or for maintenance as far as protein may be required, we should disregard zein, which, according to the table above, is 41.4 percent. of the total protein contained in corn. If we must discount the efficiency of the proteins of corn 41.4 percent. to arrive at their true value for supporting growth, then instead of corn having a nutritive ratio of 1:9 or 10, as has been commonly supposed, it has a nutritive ratio of from 1:16 to 1:20.

The nutritive ratios of the rations fed in the different trials referred to in the paper when computed on the assumption that all the protein of the corn is available for use by growing animals, and when the zein is omitted, are given in the following table, and makes an interesting comparison.

THE NUTRITIVE RATIO OF THE DIFFERENT RATIONS FED.

RATION.	Nutritive ratio on basis of total protein	Nutritive ratio without zein
EXPERIMENT No. 2.		
Corn	1:10.10	1:17.24
Corn and bone ash	1:10.10	1:17.23
Corn and blood albumen	1: 5.09	1: 6.48
Corn, albumen and bone ash.	1: 5.12	1: 6.48
EXPERIMENT No. 3.		
Corn	1: 8.88	1:15.14
Corn and ash	1: 8.87	1:15.07
Corn and protein-free skim milk	1: 9.85	1:15.77
Corn and milk protein	1: 4.32	1: 5.40
EXPERIMENT No. 4.		
Corn	1: 8.65	1:14.75
Corn and ash	1: 8.65	1:14.76
Corn and protein-free skim milk	1: 9.04	1:15.18
Corn and casein	1: 4.70	1: 6.06
Corn and milk albumen	1: 7.75	1:12.29

Unquestionably corn contains proteins that are capable of sustaining growth. Most of the pigs fed on corn alone in these experiments stored protein in their bodies. But the amount of proteins may be so small that the young animal cannot utilize or dispose of the excessive quantity of other material associated with the protein in corn. In other words, the nutritive ratio may be so wide as to render the ration unsuited to the needs of growing animals.

It is believed that the results of these experiments establish a strong presumption that for growing pigs under ordinary farm conditions it is not necessary to add to the mineral constituents of corn. It is possible that slightly increased gains and somewhat increased profits may come from allowing the pigs access to such materials as wood

ashes or finely-ground limestone, but it must be evident to anyone who studies the results of these experiments that the elementary deficiency of corn is not in the minerals.

A striking increase in the efficiency of corn was shown whenever a complete protein was added. It is true that in all trials reported, except one, there was added some ash also, and it cannot be proved positively from our experiments that both protein and ash may not be necessary, properly to supplement corn. The one trial with milk albumen taken in connection with the results obtained in a fifth trial, the results of which are not yet fully available, establish a doubt regarding the need of mineral matter in addition to that contained in corn to satisfy the demands of a rapidly-growing young animal, provided protein of the proper kind in the proper amount is supplied.

In any case, as far as the proteins available on the farm or in the markets are concerned, they all contain more mineral matter than did the proteins used in any of our experiments.

It seems to be a fair conclusion, therefore, that the farmer who is using corn as the basal grain for any class of growing animals, will find the nature, amount, and cost of the protein of the ration his chief concern.

The results of these studies are not of interest to the farmer alone. The principles are of even more importance in the nourishment of the human race. As the city population increases, the problem of providing a suitable diet for the growing child at a cost that is within the reach of the masses becomes more and more difficult.

Corn is America's most productive and widely-adapted cereal. As a source of energy it is our cheapest food. Skim milk probably will continue to be more or less of a by-product, and always will be relatively cheap. Corn meal and skim milk, foodstuffs which are among the very cheapest, and which are among those that are the most capable of the greatest expansion in production, supply all the materials necessary for the development of a large-boned, well-muscled people—the only kind of people whose civilization will endure.

INFLUENCE OF QUANTITY OF FEED UPON DIGESTION.

By Henry Prentiss Armsby,
Institute of Animal Nutrition, Pennsylvania State College.

The investigations which have been carried on for the past twelve years at the Institute of Animal Nutrition of the Pennsylvania State College have consisted to a large extent of a study of the effects of varying amounts of the same feeding stuff or mixture of feeding stuffs upon the nutritive balance, and especially upon the energy balance, of cattle. Such studies necessarily include determinations of the amounts of feed energy which escape from the animal unused in the feces, urine and combustible gases excreted, and the results of these determinations throw some light upon the influence of the quantity of feed upon the digestive processes. The comparisons here reported are in every instance between *different amounts of the same ration;* i. e., they deal with the influence of quantity and do not touch the question of the influence of heavy grain feeding. Furthermore, they relate to comparatively light feeding, many of the periods having been upon submaintenance rations, while the total dry matter of the feed seldom reached 18 lbs. per 1,000 lbs. live weight. In all, the experiments up to the end of 1912 include thirty-three cases in which different amounts either of a single feeding stuff or of an identical mixed ration were consumed by the same animal in different periods of the same experiment under conditions as nearly uniform as it was possible to make them.

The most marked effect was that upon the methane production. In a single instance (on alfalfa hay and grain) the evolution of methane was relatively greater on the heavier of the two rations and in another case (on corn stover) no difference was observed. In two instances, the determination of the methane was believed to be erroneous. In the remaining twenty-nine cases the quantity of methane formed per kilogram of dry matter eaten was distinctly greater on the lighter ration, the difference ranging from 0.375 to 6.744 gramms. In other words, as might be anti-

cipated, the bacterial fermentation of the carbohydrates in the digestive tract of cattle appears to proceed to a distinctly greater extent on light than on heavy rations. The differences tended on the whole to be less on rations consisting exclusively of coarse fodder than on the mixed rations, with their larger proportion of readily soluble carbohydrates.

It is of interest to note also that a larger percentage of the feed energy was excreted in the urine on the lighter rations in twenty-eight cases out of the thirty-three, the exception being two experiments on alfalfa hay, two on clover hay and one on alfalfa meal. Of these twenty-eight cases, there is one in which the difference amounts to only 0.02 percent. and two in which it is 0.04 percent. of the total energy of the feed. In the remaining twenty-five it ranges from 0.12 percent. to 0.78 percent. This greater relative loss in the urine on the lighter rations cannot be attributed to the presence of nitrogenous substances derived from an increased katabolism of body protein since the energy content of the urine was at least approximately corrected to nitrogen equilibrium. Since it is well established that the urine of cattle contains a considerable quantity of non-nitrogenous substances of some sort, it seems not impossible that the more extensive fermentation on the lighter ration may have resulted in an increase of these unknown constituents, although Kellner failed to find any such increase when starch or paper pulp were added to basal rations.

The results regarding the losses in the feces are by no means so uniform as in the case of the methane and of the urine. In twenty-two out of the thirty-three cases there is a distinctly smaller relative loss of energy in the feces with the lighter rations, *i. e.*, a greater apparent digestibility, the difference in the percentage ranging from 0.28 to 8.45. In the other third of the cases, however, the difference is in the opposite direction, ranging from 0.37 to 2.74, with the exception of one case of practical equality, so that it appears that other factors besides the extent of the methane formentation affect the percentage digestibility. Whether the relative loss in the feces increases or decreases with an increase of the ration seems to bear no

relation to the total quantity of feed consumed either per head or per 500 kilograms live weight. The ten instances in which a greater percentage digestibility was observed on the heavier ration include, it is true, the more extreme rations as regards total quantity but the averages for the two groups are not widely different. (4,376 grams and 3,952 grams of dry matter.)

The bearing of the foregoing facts upon the percentage of the feed energy which is metabolizable, *i. e.*, convertible into the kinetic form in the body, is obvious. The fermentation which plays so large a part in the digestive processes of ruminants being relatively more intense on the lighter ration, results in the breaking down of a portion of the carbohydrates which presumably would otherwise have passed into the feces and in a greater loss of chemical energy in the methane, accompanied in most instances by an increased loss in the urine also. On the other hand, however, the organic acids resulting from the fermentation are resorbed and oxidized in the body while the fermentation itself serves as a source of heat. Consequently, while part of the chemical energy of the additional dry matter digested escapes in the methane and urine, the remainder goes to increase the metabolizable energy. The total effect, then, of an increase in the intensity of the fermentation under these circumstances would be an increase in the percentage of the total energy of the food which is metabolizable. This is, of course, quite distinct from an increased methane production arising from the bacterial fermentation of carbohydrates which might otherwise be digested by the enzyms of the intestines. In such a case the additional methane evolved would represent a direct loss of chemical energy which might otherwise have been metabolized.

Out of the twenty-two cases in which the apparent digestibility increased as the amount of feed consumed was diminished, the percentage of energy metabolized did in fact increase in nineteen while in the remaining three cases the greater losses in methane and urine overbalanced the effect of the increased digestibility. In other words, the increase in digestibility in these three cases is less than

should correspond to the increased fermentation. In each of the ten instances in which the digestibility was less on the lighter rations, the percentage of the feed energy metabolizable shows a corresponding decrease, so that of the entire thirty-three comparisons, fourteen show a greater and nineteen a less percentage metabolizable on the lighter as compared with the heavier rations. On the whole, then, differences in amount of feed consumed, within the limits of these experiments, failed to show any unmistakable effect upon the amount of energy actually liberated in the body from a unit weight of feed. Moreover, it must be borne in mind that a considerable part of the additional energy secured by the more extensive fermentation of the lighter ration is liberated in the digestive tract as heat of fermentation and does not enter into the energy exchange of the body tissues, so that the difference in the net nutritive effect is likely to be less than that in the metabolizable energy as ordinarily defined.

THE COUNTY EXPERIMENT FARM.

By C. E. Thorne,
Ohio Experiment Station.

From its organization the open field has been the chief research laboratory of the Ohio Experiment Station. Yielding to none in estimation of the value of the work which can only be performed by the aid of the balance, the microscope, and the chemist's reagents, we have believed that there is a very large place for a method of scientific research in which these accessories are held strictly tributary to the study of the soil as it lies in the open field.

After having spent ten years in what might be termed a reconnaissance survey, during which some lessons were learned respecting the factors which militate for and against success in this method of investigation, the Station was permitted to relocate, and to apply the experience it had gained in the selection of a soil exceptionally suited to field experiment.

This ten-year experience, however, had taught us that no single field or farm can adequately represent all the soil types and climatic conditions of such a State as Ohio, and before the Station's relocation steps had been taken looking towards the bringing of other soils under observation.

The Hatch Act had just been enacted, an Act, like the preceding Morrill Act, which was far in advance of the average public sentiment, and was only made possible through the prophetic vision of a few men, and legislators generally were slow to believe in the wisdom of appropriating the money of the State for research of any description; hence it was not possible to secure funds for the purchase and maintenance of farms to be devoted exclusively to this work. Even in the relocation of the Experiment Station, the legislature provided that the necessary funds should be provided by a referendum vote of the people in the county in which the Station should be located, just as had been done twenty years earlier in the location of the college organized under the Morrill Act.

Under these circumstances the logical method of re-

search extension seemed to be to secure the cooperation of farmers in making experiments on their own land under the direction of the experiment station. It seemed that this method should have the double advantage of affording opportunity to the experiment station to enlarge its work and of interesting more farmers in that work.

But a longer experience in field research has developed serious difficulties in this method, the most important of which are that the work must be continued over a longer period than most farmers are willing to undertake to carry it, in order to produce definite results, and that it must have closer attention than a farmer who has to look elsewhere for his chief source of income can afford to give it.

To those who have had experience in field research I need only mention the fact that seasonal conditions materially affect the outcome of a field experiment, and that it is only by carrying it through a long period that data can be obtained upon which trustworthy conclusions may be formulated.

In the Ohio Station's experience there have been several cases in which the normal outcome of the experiment was completely reversed by seasonal conditions. In some cases these accidents were beyond human control, while in others they were due to failure to perform work at the proper time. For example, as an average, acid phosphate has increased the yield of wheat on the Station farms by more than seven bushels per acre, but one season every plot receiving acid phosphate produced less wheat than the unfertilized land adjoining. In another case an experimental field of clover was allowed to wait while a larger field was being harvested; then a three-weeks period of rainy weather set in, and the fertilized clover lodged and lost much of its foliage, so that less hay was secured from the fertilized than from the unfertilized land, although earlier observation had shown that the growth was larger on the fertilized land, as it has been in every other one of the 19 crops grown in this test. From the farmer's viewpoint, the large field, which was saved in fine condition, was far more valuable than the experiment. It is very difficult for

him to realize that an experiment may be worth many times more than the crop grown in making it.

Another difficulty has been that farmers are often unwilling to leave the necessary checks. In an orchard test the owner soon discovered that the untreated trees were producing nothing, while the treated trees were loaded with fruit, and he objected to the continuance of the checks. He was satisfied with a single season's work. We knew that the work should be continued longer.

For these reasons we have abandoned cooperative work, except for certain temporary experiments, which may yield useful results in one or two seasons, or which are undertaken as demonstrations, rather than as investigations.

In a few cases, where it seemed imperative that the study of special problems should be undertaken, for which the conditions at the experiment station were unsuited, we have leased farms on ten-year leases with option of purchase; the farms thus leased being of sufficient size to justify the employment of one or more men by the year, who are responsible to the Experiment Station only, and whose whole interest, therefore, lies in the satisfactory execution of the Station's work. Two of these leases have matured, and the money has been appropriated for the purchase of the land, the work having demonstrated its usefulness.

The outcome of the work at the main station and on these leased farms has led to the enactment of a law under which any county in the State may, by referendum vote, establish and equip an experiment farm and place it under the management of the central Station. Five such farms have been established, and sixteen counties have voted on the question at the election just held.

In planning the work of these outlying farms, whether of the four district farms established before the county experiment farm law was passed, or of the five county farms organized under that law, regard is had to the agricultural conditions of the region in which the farm is located. The first district farm, that at Strongsville, Cuyahoga County, was procured in order to study a special type of soil, very different in character from that on which the

Experiment Station is located. The farm at Carpenter was set to the study of the hill country conditions of southeastern Ohio; the Germantown farm was organized for the study of the tobacco crop; Pauling County is located in an area in which the production of beet sugar has become a prominent industry, and the culture of the sugar beet is made a leading feature of the work of the experiment farm of that county. The largest trucking industry in the State has been built up near Marietta, in Washington County, and the study of truck crops is to receive special attention on the experiment farm in that county. In all these cases the work selected as the leading feature is work for which the central farm is wholly unsuited, because of climatic or soil conditions. On each of these farms, however, certain portions of the work are articulated with that of the main station, and all the work which requires the equipment of the physical, chemical or biological laboratory is performed at the main station, or at temporary field laboratories established when conditions require it, with the county farm as headquarters.

In the administration of these farms the immediate management of the farm is under a working foreman, whose salary, together with that of other field laborers, is paid from sales of produce or from funds furnished by the county, each county being required by the law to provide annually for this purpose such amounts, not exceeding $2,000, as may be required by the governing board of the experiment station.

Over the farm foreman in authority is the County Agricultural Agent, who will act as general superintendent of the farm, under the Director of the Experiment Station, but who, as agricultural agent, will be subject to the direction of the College of Agriculture. This part of the plan has been criticised as providing for a dual responsibility, which is seldom successful, and as placing an additional burden upon the County Agent.

With respect to the first objection, the College of Agriculture and the Experiment Station should be, and in Ohio are, equally interested in the work of the county experi-

ment farms, both from the investigational and the demonstrational sides, for the work is indispensable to that thorough knowledge of the agricultural conditions of the State which both institutions require for their most effective work; furthermore, both institutions are represented in the government of the experiment station and in the direction of the extension work of the College of Agriculture, and it is believed that, under such conditions, a way will be found for making this part of the plan operable.

With respect to the second objection, we believe that the county experiment farm is essential to the continuity of the work of the county agricultural agent. In the first enthusiasm respecting a new enterprise a few men may be willing to tax themselves for the benefit of their neighbors, but unless human nature undergoes a radical change this enthusiasm will cool after a time, and it will become more difficult to provide means by private subscription for continuing this work. Furthermore, while the county agent may employ himself for a time very profitably in organizing his constituency and in making available the information already accumulated, the time will come when he will urgently feel, if he measures up to the size of his undertaking, the need of the more definite knowledge concerning the local problems of his county which can only be obtained by the aid of an experiment farm. We believe, therefore, that the county experiment farm will be found indispensable to the most effective work of the county agricultural agent, and as it requires several years to get an experiment farm into operation, we believe it to be highly important that the establishment of the experiment farm should go hand in hand with the appointment of the county agricultural agent, and therefore the policy has been adopted in Ohio of appointing county agricultural agents only in counties which provide county experiment farms. And we believe, further, that the men who rise to the highest efficiency as county agricultural agents will look upon their experiment farms, not as burdens, but as being an indispensable feature of equipment for their work.

As a further step in the plan of organization there will

be organized in the experiment station a department to have charge of the general business management of the county experiment farms, and whose chief will visit these farms at frequent intervals, to inspect and coordinate their work, while in the College of Agriculture a similar department will be organized, under a leader who will exercise a general oversight over the county extension work.

It will be seen that this plan in its entirety contemplates a closely-knit organization of the agricultural research and extension activities of the State, under which the work will be State-wide in its operation. The county experiment farms will be integral parts of the experiment station, and the whole work will be directly tributary to the educational activities of the College of Agriculture.

While each county experiment farm will be used by the experiment station as an instrument of research, its work will be so planned and conducted as to have great demonstrative value. In fact, the most effective demonstrations are those which contribute to research. For this reason it would seem that no question can be raised respecting the propriety of the County Agricultural Agent receiving his salary under the Smith-Lever Act, because of the service he may render as superintendent of the county experiment farm; for that Act distinctly provides for demonstrational work.

The weak point in this plan is the referendum. The Ohio Station probably publishes quite as large an edition of its bulletins, in proportion to the agricultural population of the State, as any other station in the nation, and yet not more than one in four of the farmers of Ohio has considered it worth while to risk a one-cent postal card in asking for these bulletins; and when the proposition to establish a county experiment farm has been submitted to the people of a county, it has been defeated in the great majority of cases, and by the farmers themselves; when it has been carried it has usually been by the votes of the towns. I do not believe that the Ohio Experiment Station, or the Ohio College of Agriculture, are relatively unpopular, as compared with the similar institutions in other States,

and yet, I have no doubt that if the continued existence of the Ohio Experiment Station, or of the Ohio College of Agriculture, were submitted to a vote of the farmers of Ohio, these institutions would be promptly sent to the scrap heap.

I doubt whether one farmer in fifty in the United States would have indorsed the Morrill Act, when it was passed; and probably not many more would have favored the Hatch Act, if the support of the institutions created by these acts had been conditioned upon direct taxation. This is not a pleasant thing to say, but I believe it to correctly represent the attitude of mind of the average farmer; an attitude which rests content with crop yields which return to the producer but a bare existence; which resents any suggestion of advice based upon scientific knowledge as presumptuous; which is ready to accuse those who are giving their energies without reserve to the accumulation and dissemination of such knowledge of being idle grafters; which, to use the language of Gail Hamilton, "Glories in the goad."

I am speaking of the *average* farmer, not of the thousands of farmers in Ohio and each of the other States, whose intelligent and faithful support has made possible the progress in agricultural education and in educated agriculture that has been achieved in the half century since the enactment of the Morrill Act.

EXPERIMENT STATION RESEARCH AS SEEN FROM WITHIN AND WITHOUT.

By H. J. Wheeler,
Boston, Massachusetts.

Having been for twenty-six years in the closest touch with the constituency which these institutions are immediately serving, it was but natural to forget that these men by no means represent the great commercial, manufacturing, and financial interests of the country, and that a false idea of the extent of public appreciation of the work of the experiment stations, especially by the great mass of the people of the cities, may have been gained. Those station investigators in the distinctly agricultural States have little cause to consider the effect of the city viewpoint, whereas those in States possessing a great urban population, with all the varied interests which it represents, will doubtless come to realize something of that which has impressed me since my closer contact with men engaged in these other industries. A suggestion of the point of view of the Eastern urbanite is afforded by what occurred a few years ago at a great "boom banquet" held in one of the larger New England cities, at which all of the important interests of the State were supposed to be represented. The development of trade, manufacturing, dock and harbor improvement, and practically every phase of human activity was discussed by the speakers, excepting agriculture and rural betterment. This fact showed that agriculture, the fundamental industry of the country, was quite forgotten or neglected. Then came the great rise in the cost of human food which has been a potent factor in at last bringing the importance of agriculture and agricultural research to the serious attention of the public.

Notwithstanding all the expressions of appreciation which have since been heard concerning the agricultural experiment stations and the results achieved by the research workers connected with them, the great urban rank and file as well as many of the conspicuous leaders in civic affairs in the East have, nevertheless, today little knowl-

edge and conception of what the experiment stations have actually done and are now doing for them and for the welfare of the whole country. In the South, Middle West, and West the conditions are better. It has been a revelation to find how many men of intelligence and of great business foresight in our Eastern cities still look upon these institutions as a joke and the experiment station employees as wards of the State, who take these positions because they are too lacking in energy and ability to compete with their fellows in the arena of business. Such ideas can only be successfully dispelled by launching a campaign of publicity for the purpose of setting forth the inestimable value of the work of these stations. Such a campaign should be carried by effective means to the people of all the great cities of the United States, for it will broaden their horizon, better their perspective, and develop that appreciation and support of scientific accomplishment in all lines without which no country can become prosperous and truly great.

In order to secure this publicity the daily press must be led to appreciate that well-chosen, timely and newsily-written references to the results of the work of these stations will command far more favor and commendation from the great mass of intelligent readers than long, tedious, and offensive criminal narrations. The city press has here an opportunity and a duty. In this regard many of the great dailies of the South, West, and Middle West are far in advance of those of the East, which have adhered more closely to ancient precedent. It is neither necessary nor desirable that the city press should undertake the work of agricultural instruction, but only that of disseminating agricultural news. The former is the distinctive field of the agricultural press and it should remain so.

There are still other means of reaching the city man. In this respect the Boston Chamber of Commerce is taking a notable lead. Its courses of evening agricultural lectures, in co-operation with the Massachusetts Agricultural College, which are held in the City of Boston, are being attended by hundreds of business men of all classes, and with-

in a week one of the active participators in the work of the Chamber stated that the movement seemed destined to require some permanent, effective, and special organization, in order to meet this phenomenal demand. Since my sojourn in Boston I have been profoundly impressed by the rapidly increasing number of men in the financial district who own farms and are seeking agricultural advice and assistance. From all this, it will be observed that the ferment has taken hold even in old-fashioned conservative Boston, and it must be spread there and elsewhere by these and other means until it has permeated the civic life and activity of all the great cities of the country.

What has been advocated is not the hasty inadvised rushing into print with new hypotheses and theories, but rather the acquainting of city people with the facts already established and with their important bearing upon the problem of housing, feeding, and clothing our population.

Another feature of experiment station activity which cannot be too strongly emphasized is the importance of testing, practically, the bearing of experimental discoveries under the varied soil and climatic conditions of each State where they may be of service. This means the making of co-operative tests on individual farms. These locations must be carefully selected as concerns the character of the soil and other essential features. Results which are secured in the laboratory, in pot culture, or even on small experimental plots on the college farm, should be tested widely, with beneficial results, before sweeping conclusions are drawn regarding their general agricultural importance. Then and not before should the results be disseminated by extension departments. As seen from within and without, I am convinced that this feature of station work should be greatly enlarged.

During the pioneer years the experiment station investigators seized upon all, or most, of the problems in sight which appeared to be capable of easy and quick solution. The difficult, time-consuming, and possibly insoluble, problems had little or no attraction for poorly-trained men; nor even for men of good training who were forced to

seek a living wage elsewhere, whose tenure of office was consequently uncertain, and who had little prospect of carrying anything to a conclusion. For these reasons, superficiality became at the outset the natural order of the day.

Unfortunately, there has not been the expected spontaneous increase in the attacks on big problems or in the number of men qualified for agricultural research. Politics in some cases and poor salaries in others have resulted in such frequent migrations of experiment station employees that there has been little opportunity to develop any particular line of work in certain of the stations with the hope of carrying it to final fruition.

What can be accomplished by long-continued, persistent research in one institution is splendidly illustrated by the work on soils by Hilgard and Loughridge in California; on milk and cheese by Van Slyke in New York, and by Babcock and his co-workers in Wisconsin; on tobacco by Jenkins in Connecticut; on proteins by Osborne in Connecticut; on soils, fertilizers and crop production by Thorne in Ohio; on plant nutrition by Hartwell and Pember in Rhode Island; on animal feeding by Waters and Trowbridge in Missouri; on intricate poultry problems by Hadley and Pearl in Rhode Island and Maine; and in the scientific phases of animal nutrition by Armsby in Pennsylvania.

I regret that time and space will not permit the mention of equally meritorious work by many other men of keen perception, and talent for research. What has been accomplished by these and others fills us all with pride.

It is unfortunate that not all of the stations have been presided over in the past by men competent to direct and lead real research. Certain institutions have, unfortunately, been dominated by politics, graft has wormed its way into their management, and the result has been an enormous, and in some cases an almost total, loss of potential possibilities of good to the people of such States.

As seen from within and without the great need of the agricultural experiment stations is not only better-trained Directors, in some cases, and better-trained men to direct

the research of these institutions, but also men better fitted to assist in the execution of the details of research. It would be impossible to find in the whole German Empire a Director of an agricultural experiment station who has not passed through the course of training required for the degree of Ph.D., and who has not had many years of research experience before his promotion to such a position. It would be difficult or impossible likewise to find a scientific assistant who has not at least taken his doctor's degree. Nevertheless, we are still confronted in this country by the same old situation, a fact which some station Director or college President has bemoaned for years at these annual gatherings, and still the remedy has as yet been but partially applied.

No one will deny that the opportunities for the young men just out of the agricultural colleges have steadily increased, and their chance for appointment to a professorship without further special study has been so good that they see little or no incentive to better preparation. The only remedy for this lamentable condition is absolute insistence upon a certain amount of scientific university training for all experiment station directors, and for the leaders of research in these institutions. When this is required generally, and not until then, will the younger men see the handwriting on the wall and learn that the present is the time to lay the foundation upon which to build for the future. For these research men there must also be systematic promotion and a periodic increase in salary.

It is a great misfortune that some presidents and governing boards seem to be obsessed with the idea that nothing but the work of administration is worthy of reasonable compensation, and that it is legitimate to force upon the experiment station a mere teacher, who is unfitted for research, whenever the salary budget of the college can be helped out by such a course.

We must, as a people, learn that an Osborne in his laboratory for the study of proteins, and an Armsby with his respiration apparatus, are more useful to the nation in the end and are far more deserving of reward than any mere

administrative officer. Do not understand me to say that the station directors should be paid less, for they should not, but rather that the heads of the research divisions should be paid more. This plea is not put solely on the basis of securing for them their just reward, but on the ground also that in the end it is the best economic policy for the nation.

A highly unfortunate policy is that of never raising a salary until the station is obliged to do so. What is needed for the promotion of research is a loyal spirit, hearty co-operation, and the kind of service and enthusiasm which accompany the absence of financial worry. These desirable features can usually be secured by sympathetic support and due consideration on the part of the director, and by periodic promotion for merit. An aggregation of disappointed, dissatisfied position seekers, with financial needs in the home are not in that calm, contented state of mind which is conducive to skillful planning, careful observation, clear thinking and the drawing of sound conclusions, all of which are fundamental to successful research.

This is not a time for contemplation! It should be a time for action and those station directors who have not the means to carry out these suggestions as their stations are now organized should lessen the lines of work or secure increases in their revenues, and then adhere rigidly to a program of restricting the number of projects, for this is the only course which promises relief from the present somewhat general superficiality and disinclination to undertake that which is difficult, time-consuming and truly worth while.

It may be said very properly that the research worker should be in love with his profession. The real missionary spirit should dominate him, and financial rewards should be to him a minor consideration. It is indeed true that these are the ideal qualifications of the research worker, yet many of the best men of this type are poor, and these, in the best interest of the whole country, should and must, be encouraged. It will indeed be a sorry day for agricultural research when the idea of a late bank president in

Boston prevails, to the effect that only those who can educate and support themselves by private means should fit themselves for and hold these positions.

It is a matter of serious misfortune when a truly productive research worker, who has entered the field full of the missionary enthusiasm of youth with the earnest desire to serve his fellow-men in this field more fully than he can in others, finds that his salary is not enough to support his family, to educate his children, and to enable him to dress and live in a manner properly befitting his position. When such a crisis comes he is forced to do farming on the side, become a bicycle or automobile agent, write for the press, as many station men are now doing, or he must even resign and take up some more remunerative occupation. Instead of this, he should be relieved of such distractions and be able to concentrate his thoughts on his investigations.

The remedy for these several existing conditions rests with the directors to some extent, but primarily with the presidents and governing boards, for they have control of the finances and general policy, and can, therefore, correct them if they will.

Unfortunately, many discouragements come to the station worker from the very sources from which should come sympathetic help and support. The administrative officer who cannot be constructive in his criticisms, who does not desire to gather around himself the most capable and efficient men, and who cannot rejoice over their successes and recognition by the public, is unfit for his post. Again, when comparatively uneducated members of governing boards attempt to exercise administrative functions in a station or threaten to stop all work of investigation in a given line, if the problem is not solved by a stated time, a most unfortunate condition of unrest and uncertainty is created. These actual conditions result finally in resignations and loss of desirable continuity in research.

There seems also to be a great lack of team work in many of the stations. For example, problems are continually arising in the course of field experiments with plants and fertilizers which require for their solution the combined

effort of the soil bacteriologist, chemist, and plant physiologist. It should be the prime function of the director to promote and arrange for such co-operation.

If certain of the side problems which arise in most lines of research could be attacked at once, light would often be shed upon the main question involved, but those in charge of the main line of research either lack the means, men, time or ability to attack these associated, but more remote problems, and thus the chance to seize the opportunity may be forever lost.

As a suggestion of how these opportunities may perhaps be grasped at the proper time, it is a source of particular pleasure to call attention to the growing tendency of the United States Department of Agriculture to work through and in hearty co-operation with State agencies, rather than to assume a predatory and opposing attitude. This appears to be one of the many points of view of Secretary Huston which is particularly worthy of public notice and commendation. The existence of such a spirit suggests a great opportunity for the more complete development of hearty and effective co-operation between individual experiment stations and also between the Department of Agriculture and the State stations in the study of these side problems which the individual stations cannot attack.

Suppose, for example, as in Pennsylvania and Rhode Island, a station has, through a long series of years, brought about a gradually increasing acidity or alkalinity of the soil of certain plots, but perhaps has not the laboratory equipment, men, and funds to make a study of their effect upon the physical, fungous, bacterial and other conditions of the soil. There should be in such a case some means by which the opportunity could be made known and embraced before changes in management or other causes result in the modification of the conditions, or in the entire abandonment and disruption of the experiment. Similar situations and possibilities in other lines probably exist at most stations.

It is almost impossible for a careful, observing, well-informed agricultural chemist, agronomist or soil bacteriolo-

gist, to look over in detail the work of any up-to-date experiment station, without finding some points where another station or the United States Department of Agriculture might render most important aid. It would indeed seem as if the Office of Experiment Stations might well extend its usefulness by adding to its inspection the work of discovering these side problems and of arranging for such co-operative attacks upon them as have been suggested. The stations could thus be induced to co-operate voluntarily with one another, and the United States Department of Agriculture could also be shown how it could lend its aid and co-operation. Such a man should of necessity be sympathetic in his attitude toward the department and stations; he must of necessity use tact, discretion, and good judgment; he must also be broadly trained, and then if supported properly by all, his opportunity for real service to the cause of American agriculture would be great.

As seen from without the tendency to appoint incompetent men, the occasional attempts of the colleges to force men on the stations who are unfit for research work, the lack of sufficient team work in individual stations, the desire to cover too wide a field, failure to concentrate more study on problems already undertaken, lack of sufficient cooperation with other stations in the study of regional problems and with the United States Department of Agriculture in various directions, are some of the points worthy at this time of the most careful consideration and study.

THE RELATIONSHIP OF AGRICULTURAL EXPERIMENT STATION WORK TO AGRICULTURAL EXTENSION.

By F. B. Linfield.

Progress in any direction is not, in its initiation, the product of the demand of the masses, but comes as a rule from the prophetic vision of the careful analyses of a few. The use and development of Agricultural education was no exception to this rule. A few had a vision of the possibilities of agriculture as a science—the great majority were indifferent, or even antagonistic. But the vision of the few had to become the vision and hope of the many before the dream of the few could be realized in the practice of the community.

One of the fundamental problems in agricultural educational work has been and probably is now, in many places, to convince the people whom it is planned to serve, that any person, group of people, or any institution can tell them anything that they do not know about their business. Especially is this so when the source of information is distant and impersonal.

I know whereof I speak because of the opportunity to study pioneering work in this direction in three widely separated districts of the country.

Would you pardon a personal note that will give a setting to what I wish to say in this paper? My first work after getting through college was an extension one, viz., in charge of a travelling dairy over a portion of Ontario, Canada. I went to the Utah Agricultural College twenty-one years ago. The first work there was to establish a dairy department at the college and develop a dairy industry over the State. I found that the latter was not the least of the duties on hand.

In Montana, some ten to twelve years ago, I fell heir to a group of jobs, viz., the head of the Agricultural Department of the College; the superintendency of the Farmers' Institute, and the Director of the Experiment Station. The

experience of these years seems to teach that the support needed to develop and maintain the work at the college, whether in the class-room or the experiment laboratory, depended on the utmost confidence and good will on the part of the constituency we were trying to serve, and again that a large measure of this confidence and good will came from personal contact and large acquaintance with this constituency.

Whether right or wrong in principle, it has been on this basis that we have worked and we find that it has made possible the building of strong departments of work by getting generous appropriations for the same.

As I look back over the agricultural educational development of various States, it has seemed to me that in many ways it has been the product of the agricultural extension work as represented in the beginning by the Farmers' Institutes. These meetings brought the instructor and experimenter out to the farmer and gave them first-hand information about the farmers' problems and his viewpoint. It also gave the farmer an opportunity to study at first hand the college man and to weigh the practicability of his knowledge and point of view. The result was a large growth of mutual respect, confidence and good will.

It has often been commented on particularly by those who would severely criticize, that the development of agricultural education and the service of the Agricultural College to the farming public was, for many years, slow and backward. They forgot that this field of education was wholly new and that neither were teachers available, nor methods of teaching worked out. They forgot also, the great economic revolution in agricultural practice, which has been in progress during much of this time.

It is a very interesting fact that the beginning of plans for agricultural instruction in this country was also the time of the beginnings of extensive use of machinery in agricultural work. The immediate effect on agriculture was to reduce the demands for labor and to increase the capital requirement of the farm. It made possible, too, the rapid opening up of the prairie lands of the west and, as

a consequence, an over-supply of agricultural products and a corresponding depression in prices.

Accompanying this was the effect of the nation to stimulate manufacturing, making possible higher prices for labor in the trades and industries, and larger prizes for those who could direct, plan and organize these industries.

It was through such a period of discouraging agricultural outlook with depression and reorganization to contend with in its midst, and a stimulated trade and industry surrounding it that agricultural education had its birth and early years of struggle for recognition.

Within the past ten years, conditions have approached more nearly to an equilibrium, and the prospects of the farm have correspondingly brightened. But during these years agriculture has advanced from a trade to a business. The farmer is using more machinery and power in his work. His daily productive ability measured in crop returns have been largely multiplied. His markets are world-wide. His next step forward must be a recognition of this enlarged business relationship. His problem is how to organize and co-ordinate his business with his neighbors, and his community so as to take best advantage of the new relationship. He must give up some of his independent individuality; co-operate, in production and manufacturing in the elimination of multiplicity of products, but getting larger quantity and higher quality in the remainder; co-operate in marketing to get the farm products to the consumer at the least cost and co-operate in finance to get credit that will enable him to carry on his business with the largest margin of profit. These are the problems of the next generation of farmers. It is ours to know what to do and be prepared to direct the working out of the plans.

If we fail in this matter, in some ways it would appear as though the pioneering problem would have to be done all over again and our constituency again convinced that in this new and big business problem, these institutions which they have built are yet the leaders whom they can safely follow. Our problem here gets beyond the study of things to the study of men and of humane institutions, and where

can this be done except in the field among the units making up the problem?

Those who for many years have watched the development of these institutions for service in the agricultural field, feel that in some ways a dream has been realized, and yet that this realization has brought with it responsibilities and dangers which are going to tax our best thought and endeavor to master.

Within a little more than a quarter of a century we have divided the field of agriculture into several specialties and we are not yet through with this division. We have recognized three distinct kinds of service: experimentation, school and college teaching, and extension.

In each of these fields the tendency is towards greater segregation, each worker concentrating on a narrower field of service.

One of the problems before us is how to so correlate these various agencies, that the vital facts may flow fresh, clear, free and as a united whole to the farm.

The farmer makes his living by producing crops of plants, animals, and animal products and selling the same to the best advantage. The sum of *our* work is to make more efficient his ability to produce and market his crops, thereby increasing his labor income.

Heretofore a great deal of the information we had to give dealt with broad principles, leaving the farmer to work out their application to his farm and to the business and economic conditions with which he was confronted. We are rapidly passing to a more difficult problem, viz., the giving of definite information to a particular farmer on a particular farm.

With the growth of one agricultural organization there are several agencies and many agents disseminating agricultural information to many different classes of people. This information, to be effective and efficient, must conform to some broad fundamental principles.

First, it must be accurate and reliable. Misinformation may injure our reputation, but he who depends on it may lose his income and dissipate his capital. To him, the question is a vital one. His livelihood may be at stake.

Again, this information must be practicable or usable under the conditions with which the farmer has to work. From his farm he gets his yearly income. The results of our work must stand the test of practicability in the field of profitable production.

In the third place, the information given by the different instructors must be consistent; otherwise, the conflict in ideas and teaching will destroy faith in both the instruction and the instructors and thus the effort put forth to help becomes worse than wasted.

All these things point to the necessity for a close relationship between the various agencies working to improve the agriculture of a State. The unity of the work in the three-fold field of the agricultural department must be maintained.

It would appeal to me, therefore, that the plans that were necessary to build and develop this work, while they may be modified in detail, must yet be maintained in the larger organization. The people must know and feel that the men in the class-room and laboratory understand their work and problems; are in full and hearty sympathy with them and are working faithfully and earnestly to serve.

Our field of work is one which our constituency finds is ever present with them, and where they are fairly competent to measure results.

In the pioneering stage of this teaching development, the man in the agricultural department was supposed to cover the whole field of practice, in the various special departments of the work. Even with the first division into specialists, the men were expected to cover the three-fold service of experimenter, teacher and extension lecturer. Within limits, this was good, as there was little danger of lack of co-ordination in the facts given out. The demands, however, have rapidly gotten beyond the ability of such an organization, and no man could become an expert in the modern sense of the term and meet the demands of such a situation.

Within the past few years, through a thorough study of the needs of the work, coupled with an increase in sup-

port and an increase in workers, the organization for the College and Experiment Station, best adapted to efficient service, has been fairly well worked out. The field of agriculture has been divided into specialties and a group of men set to work in each. Within these groups, some may divide their time between teaching and investigations, while others may concentrate on one or the other side of the work; yet, each is familiar with the work and problems of the others in the group.

In the expansion and reorganization of the Agricultural Extension work, which has come so rapidly with the passage of the Smith-Lever bill, it has seemed to me that the working force in the extension field must also connect with the special divisions of agriculture in the college and experiment station.

The extension organization, however, is in some ways fundamentally different from that of the College and Experiment Station. The latter are organized to deal with subjects; the former with people or groups of people.

The Farmers' Institute corps becomes in the new organization, a group of State specialists, viz., in Home Science, in Farm Management, in Agronomy, in Horticulture, in Animal Industry, etc., etc.

These specialists may perform the same type of work as the Farmers' Institute Corps, but they are also special advisers to the field county men on the many special problems that are continually coming to them. They may also advise with individual farmers as occasion may demand. To this group of men should go the bulk of the correspondence that is asking for information on a great variety of agricultural topics.

These specialists are a part of the various departments in the College, to which their work is related and give voice to the results and experiences which the teacher and investigator have found to be safe; while they also contribute to the information of the Department from their wealth of field experience. But, while physically connected with and associated with these departments, their time and service are under the direction of the Extension Division.

In the initiatory organization, some of these extension specialists may give a part of the year to experimental work, or to college or school teaching, thus dividing their time between two divisions of the work as is now the case between the college and experiment station.

Another part of this extension organization will be the county or district agriculturist, presided over by a State leader, who plans and directs their work. The whole field of agriculture is their province, because they must deal with all the agricultural interests of their county or district. They are general practitioners who, like their namesakes in the medical profession, know their limitations and call in the specialist whenever occasion demands.

They are local centers for the distribution of agricultural information; for the planning and advertising of farm meetings; for the working up of co-operative enterprises in production, manufacturing, marketing, etc., etc.

But the extension work should also try and reach the boys and girls of the farm, and interest them in the work of their parents. This should be done through an extension department in agricultural education. Such a department should keep in close touch with the county teacher and the county schools, and interest the patrons of the school and the teachers in the work and problems of the farm.

An important part of this work will be the organizing of boys' and girls' clubs to interest the young people in a better agriculture.

To reach a still larger constituency, and reach them more frequently, there should be organized a department of agricultural information in charge of an experienced news man, who knows how to make agricultural information valuable to the country press and yet interesting and attractive to the country reader.

Such an organization of the extension division, as above outlined, should be a great help to the experiment station. It should relieve it of much correspondence in answering questions about general agricultural topics, and reduce the demands upon it for extension work to a desirable minimum. It will permit of greater concentration on the

agricultural problems in hand and yet, through the extension agent in its departments, it would be kept in close touch with the problems and needs of the constituency.

Finally, I would like to make all of these workers, whether engaged by the experiment station, the college, or the extension service, a part of the agricultural faculty, under one head. They will then get acquainted with each other and the problems of each become the interest of all. It will help towards a full realization that, while the work may differ, the end is one, viz., a better agriculture and a more enlightened, prosperous and contented farming community.

TEAM WORK IN AGRICULTURAL SCIENCE.

By R. J. H. DeLoach,
Georgia Experiment Station.

In order to divest our minds of any intention on the part of the reader to discuss here the question of agricultural teams for hauling or ploughing, we shall take pleasure in setting forth in the beginning what the heading of this paper is designed to include. In Webster's New International Dictionary we find, under the heading the following which almost serves our purpose: "A number of persons associated together in any work; especially a number of persons selected to continue on one side in a match, or a series of matches, as in cricket, football, rowing and the like." The Anglo-Saxon word *team* means off-spring, progeny, family. Added to the modern definition this older meaning helps to bring out the fullness of the word, and it has occurred to me to discuss it in the present paper.

Any form of scientific work pre-supposes a wholesome atmosphere. This is almost impossible without a well-regulated community of kindred spirits, if there is a community at all. The original meaning of our word team—which is family—approaches the ideal when applied to experiment station work—a body or family of people with kindred tastes—eating at the same table—drinking from the same cup of knowledge, having a common purpose; all striving for a common goal. The idea of the game of ball does not overdraw the figure. Those of us who have ever played a game of baseball or football can well picture what it means for the team to be in harmony, and for all the boys to have in mind the welfare of the team. I shall find it convenient to raise a few terms applied to the game.

This is what we mean by team work in agricultural science. For the men in the various departments to pull together so that the game may be won. Humanity is to be organized on one side—the great mass of unknown facts existing on the other. We are to have a real game of it, trying to discover the new and the unknown. Every man in the team must be on the line with his eyes open and his

mind thoroughly trained, and his heart in the work if the battle is to be won.

A good leader makes a good team—in fact, he must carefully study the material with which he is to begin the battle, and know how to line up the men. He must continually lend a little encouragement and inspiration, and be able at all times to show the weak places in the line as well as the evidence of progress in the game.

Coming now to a more practical application of our figure, more than half the efforts of all agricultural experiment stations have been wasted in the past on account of lost motion in the work, on account of lack of organization. Merely to have a director and several departments is not sufficient. A proper conception of the possibilities of the work, and an appreciation of its broad application, will go a long way toward success. It seems to me that agricultural science must be put on high ground before you can kindle enthusiasm in the minds of investigators. The old theory of applied Science and Pure Science is to my mind a myth. Science that has no application will not go very far today. If Astrology and Alchemy could be considered in any sense pure science, Astronomy and Chemistry are *Sciences—pure and applied*. Establish this fact in the minds of your team of agricultural workers, and you have made a touch-down—so to speak. Men love to think that they are engaged in work that is of great importance, and when they are made to feel this way they develop the proper spirit for work. Let this fact be fixed in their minds and organization becomes easy. Let them develop the ancient notion that agricultural science is for the elementary student, the novice, while all the real scholars follow other lines of science, and organization is practically impossible. In other words, the genuineness and the spirit of the organization will depend almost entirely on the breadth of view held by the leader, who must be one of proper training in the agricultural sciences, and must be able to take hold along almost any line but especially well trained in some particular field of agricultural science. He should be respected not only for his executive ability, which is in-

dispensable, but on account of his own success as an investigator of truth. If he is narrow-minded and leans to the practical and to the superficial at the expense of the fundamental principles of science, the entire organization will be weakened. Men of any real worth will become discouraged, and the institution will have the stamp of superficiality placed upon it. Good men in the organization may be respected, but the institution itself will not draw the best talent, because of this lack of breadth of view.

Can an Agronomist work out any important soil problem without a carefully thought out and wrought out plan of co-operation with a Chemist and Bacteriologist? Can an agricultural Botanist do his best service to science and to the Institution he is serving without combining his efforts with other departments? To merely work out the life history of a fungus, which can be almost guessed at in the premises, could not be considered of much importance in most cases. To know the economic importance of the fungus and to plan a broad campaign of science in the study, is to recognize the necessity of close and sympathetic co-operation with a Horticulturist or an Agronomist, or whatever department the particular line of investigation happens to be most closely associated.

Projects can be developed more systematically and perhaps more effectively when discussed thoroughly and planned by committees or even the whole station organization than when planned and stated by individuals. This may not be true in every instance, but it certainly is true in a general way. At the Georgia Station we have a committee on projects, and whenever a new line of investigation is to be taken up it is first referred to this committee, which threshes it out and feels free to make criticisms and suggestions. In this way, the organization is made to feel an interest in, and some responsibility for, what the station is doing, and especially in what it might undertake to the best advantage. We have, in like manner, committees for other phases of the work. In fact, this we find to be an essential feature of our team work. The station organization is small, but none the less active and enthusiastic. Every man

in the organization enters into the spirit of the work as a unit, as well as into the work of his own department. We are sometimes inclined to ask the questions, How exclusive should a staff officer consider the laboratory provided for him? Should members of the staff feel free to visit and work in laboratories other than those provided for the particular department? Should there be more than one chemistry, or bacteriology, or botany laboratory? These discussions are valuable. They often lead to definite understandings and pleasant relationships among the various departments. We hope to have the idea prevail that the laboratories belong to the station organization, and that, while there shall be no trespassing and meddling, yet there shall be an atmosphere of freedom in these matters. Individuals who are in charge of laboratories are guardians of the station's interests, and should rejoice to help develop one efficient laboratory for each line of investigation rather than try to have conglomerate department laboratories in which something might be done in chemistry, botany, bacteriology, agronomy, and every other branch of agricultural science.

Just how the spirit of department independence should be permitted to run has been a question with us. Quoting from a periodical, we have thought about as follows: "A proper independence in the conduct of investigation, in their respective specialties, are just credit for their share in the station's operations, as set forth in publications or otherwise, may, it is believed, be amply secured for the expert officers of the station at the same time that good discipline is maintained and ample provision made for united effort." In other words, however important departments may be, the real unit of activity will always remain the institution itself. "The fame and emoluments of individual workers should be subordinated to the requirements of concerted action for a common end. The tide is running strongly toward a more compact organization and a greater unification of the work. On the whole those stations which have a strong organization and administration are meeting with the largest measure of success." This form of

organization and compactness should not exclude the idea of the field laboratory.

Team work in agricultural science should not be a matter of individual institutions. It applies, in fact, as appropriately to the State and Nation. Those States that are well organized are doing the great work in agricultural science. Where the men in the various branches of agriculture in the State's organization thoroughly understand each other and the policy of the State the work is more effective.

The Nation is doing its greatest work in those localities and along those particular lines of thought and investigations where it is systematically lined up with States and local institutions. There can be no doubt that the Nation, as a whole, should be more closely knit together in the great agricultural work it is undertaking. The sovereign rights of the various States cannot be expressed more emphatically than in requests for close relationship with the federal government in working out great agricultural problems. On agriculture the prosperity and happiness of the people will always depend, since ours is a nation of farms, and, therefore, the more nearly the country as a whole can be organized into a team, the surer we are not to go astray in the work.

In 1902, experiment stations in forty-three States and territories were co-operating with the United States Department of Agriculture in working out problems of national importance. The fact that our colleges and stations have been created by the national Congress suggests the great and fundamental importance of organization in the work. The meeting of the Association of American Agricultural Colleges and Experiment Stations, which convenes in the city tomorrow for the twenty-eighth annual convention, is evidence that the will of the national Congress has been carried out in part at least. This great gathering keeps the institutions of the country in close touch with each other. Policies are framed here, whereby the work in agriculture can be developed systematically. The station division of the American Association represents the largest single team of agricultural scientists in the world, and how

necessary it is for this great body to have a common purpose. When conditions are not favorable for this the cause of agriculture suffers.

A few years ago, one of the Southern States attempted to *bolt the game* and split up the experiment station funds into several small portions, each portion to be used in connection with small State sub-stations. Fortunately for said State, and for all the stations, the bill which passed both houses of the legislature was vetoed by the Governor of the State. The federal law had provided research funds to be used in connection with the colleges of agriculture, a fund to supplement the work of institutions maintained by federal appropriation.

The Hon. Justin S. Morrill, when asked his opinion as to the right of a State to divorce experiment station funds from the college appropriation, replied as follows: "In reply to your favor of the 6th inst., I am clearly of the opinion that the proposition before your legislature would be considered an evasion of the Hatch Act. I should regret to see it passed for the reason that it is somewhat doubtful how long this $15,000.00 appropriation will be continued, and should it be considered by Congress as having been misapplied, they would suddenly bring such appropriation to an end."

This is a just warning that so long as the institutions themselves are lined up, so to speak, they may be considered permanent, but are likely to be terminated immediately upon the exercise of any selfish policy on the part of the States themselves. The question of organization and policy is too important to be jeopardized by any local prejudices, and whenever any *bucking* on the line is passed unnoticed, the team is in danger of complete dissolution. Therefore, we may infer that Congressman Morrill had studied the importance of national organization and foresaw the serious consequences of any break in the line.

Let us not forget that the success of any organization will eventually depend on the individual men in the organization. Organization will keep men encouraged and interested, but it cannot lay the foundation for a great piece

of scientific work. The training itself is not all that is required, as important as it may be. Original work in agricultural science "requires men of genius and originality," who love, above all, the discovery of truth; men whose curiosity leads them not only to the uttermost limits of our present knowledge, but on and on into that great ocean of undiscovered truth, the discovery of some of which eventually proves a great benefaction to the human race. The problems in agricultural science are perhaps more difficult than those in other sciences, because they have arisen in practice. They are very complex because of the many factors that enter into even the simplest of them. Therefore, men who undertake to solve these problems "should have a sufficient grasp of the subject in both its practical and scientific relations to be able to analyze it and determine the point of attack." It goes without saying that this requires thorough familiarity with the field and laboratory, with the plant and the animal as well as the factors which control its well-being. Organization plus genuine investigators make the ideal institution, or *Team of Agricultural Workers.*

THE SMALL FIELD LABORATORY AND ITS ATMOSPHERE OF RESEARCH.

By David Fairchild,
U. S. Department of Agriculture.

When your Secretary, Dr. Allen, called upon me and requested me to read a paper before you I was surrounded by a pandemonium of sounds and smells. Builders were unloading steel beams in the alley below, cement workers were shoveling gravel into steel wheelbarrows under my window, and the fumes of the pitch pot were drifting in at the window. I was trying to do some research work and was surprised to find I could do it. In the next room my colleague, Mr. Dorsett, was drawing up the plans of a three-room laboratory which is now being built on our Introduction Garden at Brooksville, Florida, and when Dr. Allen wished me to suggest a subject on which I could address you, I could not help unburdening myself to him on the subject of the Atmosphere of Research which surrounded me and the advantages which the small field laboratory, which Mr. Dorsett was planning, had as a place in which to do research work. I had little idea then of trying to write on such a subject as this. Modesty alone would forbid me to pose before you, who know me so well, as a man whose research work entitles him to speak with any authority on a subject which has an implied criticism in it. Dr. Allen, however, insisted that he had heard the complaint I was making before and that you would be interested even though you might not agree with me in the presentation of the claims of the small field laboratory. This is not intended as an apology for my paper but the wish merely that someone better qualified than I should have seen fit to present the cause.

So far as any generalizations are true, I think it will be admitted to start with that discoveries in agriculture are the result of mind concentration. There may be accidental discoveries, but most of these even occur as a result of concentration. The ability to concentrate varies widely with people, and seems to be a trait of character inheritable

just as are other traits, but there is bound up in most personalities another factor which influences tremendously that of concentration—I refer to the ease with which one's mind is distracted by outside surroundings. Some of the best research minds which have left their impress on history were seemingly associated with an ability to become oblivious to what was going on around them. Archimedes was so lost in thought that the Roman soldier killed him in the midst of his geometrical reverie. Lord Kelvin worked out the method of finding the broken ends of the Atlantic cable at the home of a friend, where he had gone to spend the evening, while sitting in the middle of the drawing-room with the rugs turned back against him, and the young people dancing around his chair. They saw he was thinking and did not wish to disturb him. So I was told by Mr. Blandy, of Madeira, whose sister Lord Kelvin met later while he was superintending, in the harbor of Funchal, the carrying out of his theory, which proved the correct one. Pasteur, it is said, carried on his researches in the midst of a large family of children. I doubt if anyone will claim, however noisy, that the surroundings were of any assistance to these investigators in their studies. They were one of those necessary evils from which human beings have not yet rid themselves.

To be able to sit down in the midst of all sorts of distracting noises and changing amounts of light and shade, and in the presence of disturbing personalities, and lose one's self in a problem is an accomplishment which many people have, but even these people will, most of them, admit that it imposes an extra strain upon them, and that they do better work in the quiet seclusion of a study late at night, when the household is in bed.

In some experiments which my friend, Charles Winslow, has been making in New York, to show the effect of bad air and high temperature upon brain work of employees, he found that practically the same amount of work could be done under the unfavorable conditions as under the favorable ones. His explanation is that the organism makes a greater effort under the unfavorable conditions.

In a most instructive discussion by Dr. Blake, of Boston, he emphasizes the effect of the increasing noisiness of our city life and the numbing effect upon the tympanum, and points out how unfortunate it is that in our schools we try to teach the children to concentrate on their lessons in the midst of the continual rustle and hum of the schoolroom. He thinks it is a serious question whether man may not lose his acute hearing as a result of the terrific hammering on the tympanum by the continual din of our city life.

If there is one law that stands out most prominently in biology it is the law of response to stimulus. I am impressed by the application of this law to research work. If we subject young research men regularly to strong stimuli, is it not conceivable, indeed probable, that they will fail to react to gentler stimuli of the same kind? Can there be any question that in biological research at least, sensitiveness to minute differences in color or form and a quickness to interpret their meaning is a prerequisite of the discoverer? If a man fails to respond to the gentle stimulus which nature exerts, is he likely to make great discoveries in the agricultural sciences?

Viewed from this standpoint of stimulus, is it not worth while to consider what effect our large laboratories are having upon the men working in them and whether the small field laboratory does not afford certain distinct advantages, at least for plant investigations?

To get into the habit of feeling the need of the presence of expensive apparatus and sinks and rows of bottles, etc., in order to do biological work, may be a serious matter and I believe does, in many cases, develop men who fail to react to phenomena that are going on all around them and which, if observed by them, would lead to important discoveries. They get into the laboratory routine habit of life and thought. Their brains unconsciously come to say that outside the laboratory is not the place to work, and occurrences of great importance take place right under their noses without their seeing them, because when outside their laboratory they turn a blind side to things.

But a more serious feature than the crowded laboratory

has entered our investigational life. I refer to the executive features of Experiment Station work. The touch with the farmers and the development of the typewriter has made necessary an amount of executive work and has brought into almost every laboratory a new element in the person of the clerk, whose attitude towards research is and must always be one of impatience—impatience to get letters written and work (in the sense of pages of typewriting) done. I would be the last man to decry the usefulness of this new element, although I believe there are many abuses and much wastage of energy and good time for investigation incurred through the typewriter. But we cannot do without it.

The problem, however, which does not seem to have been worked out is the adjustment between the research atmosphere and the executive atmosphere. We try to mix them, turning from one to the other with the agility almost of a professional impersonator. We are called out of the laboratory, for example, to decide one of those distressingly upsetting questions of clerical discipline, involving personalities, and go back to our studies wondering whether the decision we have made is going to change our personal friendly relations with some other worker. As an executive, while one is expected to sift a situation to the bottom, he is obliged to make a decision; some kind of a decision must be made, whereas in research work the important thing is the discovery of a fact and the decision of some action regarding the fact is not forced upon you as imperatively as it is in the case of executive problems. In other words, it is not an easy matter, surrounded by the executive atmosphere, to settle down to good research work.

Now, my plea is that our great laboratories are invaded more than we perhaps realize by the executive atmosphere, and their very size and the fact that they are under one roof makes this invasion almost unavoidable. Everyone recognizes that there is a great difference between the personal atmosphere of an apartment house and that of a private detached dwelling, although it may be difficult to analyze this difference. Our large laboratory buildings, with their common hallways, elevators, and class-rooms,

which are thronged with more or less quiet young people, are not pervaded even by the stillness of our best apartment houses, and the laboratories, where quiet should prevail, generally resound to the echoes of conversation or footfalls, or the click of the typewriter.

Uninterrupted periods of quiet are (as I conceive the problem) what we need in order to increase the output of valuable agricultural discovery. I am speaking from my own limited experience only. There are doubtless many laboratory men who have all they want of this uninterrupted quiet, but I must say it has not been my good fortune to meet many of them.

It will be admitted, I believe, by most people that there is wasted energy in the stopping and starting of a train of thought as there is in the starting and stopping of an engine; and the deeper the degree of concentration the longer it takes to pick up the train of thought after an interruption.

Mr. Graham Bell, for example, has expressed the belief that his own brain does not get into easy working swing until it has been concentrated for several hours upon a subject, and I have had occasion several times to notice that twenty-four, or even forty-eight, hours of almost continuous concentration do not seem to weary it. Yet an interruption, be it ever so slight, often leads Mr. Bell to abandon for the time being any attempt to prosecute the studies in which he is interested.

Presumably, legislators are warranted in believing, when they have appropriated large sums of money for laboratory buildings, that they have provided ideal conditions for research and some, perhaps many, will declare that if the botanists or the entomologists cannot do their best work in these palaces then we had better get those who can. I have no quarrel with the big palaces of research. They are necessary, and it is right that the State should dignify research by permanent structures of an imposing character. I think it is unfair, however, not to point out their limitations and search for any accessories which will supplement them and make them more effective.

Narrowing the discussion to a study of plants, and com-

ing to the point of this paper, I wish to indicate a few of the ways in which the big marble laboratory is disappointing to the botanist, and suggest the erection of small field laboratories for plant study.

It may seem a small matter that the laboratory is a few hundred yards from the fields of growing plants, and of only minor importance that the botanist lives a few miles away from the Station. He can carry his plants for study to his laboratory and he can come as early as he wants to the Station.

Let us analyze these matters and find if, after all, they are really unimportant. The period of greatest research activity of an investigator, the period of best eyesight, lies, let us say, between his 20th and his 60th year, which means that he has only forty springs and forty summers and forty autumns in which to make his observations. But not all periods of these seasons have the same importance. A plant, like a comet, moves rapidly in its orbit of life cycle changes, and unless the observer is on hand at the critical moment he is just as much too late as the astronomer who is napping in his observatory when the fixed star he is watching passes unobserved the cross hairs in his telescope. The phenomena of germination, of bursting winter buds, of opening flowers, of fertilization, of frost injury, are matters of hours and occur only once a year, or forty times in the actual life of an investigator. Do our large laboratories, far removed from the plants, surrounded by lawns and shrubbery, offer the facilities they seem to do to the investigator at these critical times?

Any plant hybridizer is aware that there are certain hours during which plants can be hybridized, and unless they are crossed at the correct time a whole year's effort may be lost. With many plants this optimum time is in the early morning, just as the bees begin to fly. Has this fact been taken into consideration by the botanist who lives a mile or so from the Station? Any plant enthusiast realizes that the best time to work in a garden is in the early morning, and why should this best time not be utilized by placing at the botanist's disposal the facilities for its use—a small

field laboratory among his plants, where he can spend the night and be on hand at sunrise.

From my own personal experience with small field laboratories I venture to predict that such laboratories, if properly placed, would become veritable retreats for the botanical workers—places where they could go and work quietly with their plant problems without fear of interruption and surrounded by an atmosphere of their own making, which would stimulate research in a peculiar and effective way.

It is true that many of them have dens of their own in their own homes. These are generally the older men, and even with them the encroachment of home responsibilities is often an important and disturbing factor.

Had there been opportunity, I should have shown on the screen some views of field laboratories which I have seen, in order to illustrate my point. As testimony that they do mean much to an investigator, I can say that they form a delightful background, playing the same stimulating part in my life that the old alchemist's laboratory doubtless has played in the lives of many chemists. They add a romance to any discovery which I find it is difficult to attach to a great building full of people.

I would like to have shown you Tjibodas, the little laboratory which that remarkable botanist, Treub, built on the slope of the Volcano Gedeh in the island of Java, on the edge of the virgin forest. There would have been a view of the first sub-tropical laboratory built by Swingle and Webber, in Eustis, Florida; another of the Miami laboratory and sub-tropical garden and superintendent's house in the midst of newly-introduced plants; one of the Carnegie Desert Laboratory in Arizona; one of Mr. Drummond and his little greenhouse and dwelling house in the Indio date gardens in California. I intended getting one of the home and garden of the plant breeder, Dr. Van Fleet, in New Jersey, showing how convenient everything was for early morning studies, and another of John Burroughs' Slabsides, out of which so many nature observations have come; and if time had permitted I should like to have shown you Mr. Graham Bell's houseboat retreat in Nova Scotia, to which every Saturday he withdraws, and in which he leads

a hermit life until the following Monday morning. I doubt if anywhere there could be found a place which would appeal more to the romantic spirit of a research man than does this old houseboat drawn up on the beach, a mile away from anywhere, in which for twenty years Mr. Bell has worked alone.

If you will pardon me in a discussion of this kind, I would like to refer to my own experiences in European institutions of learning to whose atmosphere of pure research my mind often goes back with longing, although I recognize fully that these institutions were not then closely enough in sympathy with the pressing problems of agriculture to furnish much immediate aid to the farming classes of their country.

The Zoological Station at Naples had, in 1894, an atmosphere of research which left a lasting impression on me. The quiet of that institution was the quiet of a monastery, and I believe everyone who has been there will agree with me that it is one of the best places in the world in which to work.

The botanical laboratory of Ferdinand Cohn, situated in the midst of the small but good botanical garden at Breslau furnished admirable surroundings, but was beginning then, in 1895, to be too crowded with young people.

The Landwirtschaftliche Institute, in Berlin, and the Institute at the Royal Botanic Garden, then situated in the center of the city, I found poor places to do research in, and, while glad of the many acquaintances made there, I always felt the absence of a real stimulus to discovery in its atmosphere. There was too much going on. Conditions at Dahlem, where the new garden is situated, are, I understand, much improved.

Brefeld's little laboratory in his own house in Münster, where I first met my friend R. A. Harper, now Professor of Botany at Columbia, convinced me that an expensive laboratory was not necessary for good work.

Strasburger, in his laboratory in the old palace in Bonn, where $600 a year was the government allotment of funds for apparatus, furnished a stimulating atmosphere which none who ever studied in it could forget.

Professor Borzi, at Palermo, had a little laboratory within a dozen yards of all sorts of interesting sub-tropical plants, and I first got a glimpse of the fascination of this southern botany from working side by side with a young Italian student there.

The simple one-story tropical laboratory at the 'S Lands Plantentuin of Buitenzorg, Java, was an ideal place for study because of its close proximity to a wealth of plant material. The little mountain laboratory at Tjibodas and the field laboratory which my friend Lotsy, now editor of the *Botanisches Centralblatt,* erected in the Cinchona plantation at Sindanglaja, will stand out in my memory as wonderful places in which to work, notwithstanding all their drawbacks of laboratory inconveniences.

The acquaintances and friendships made amid the simple surroundings of such field laboratories as I have had the temerity to propose would play a most important role in the lives of our scientific men and tie them together in a way which no amount of formal convention meeting can possibly do.

To my mind, therefore, the field laboratory would afford the following facilities for research which our large ones do not adequately afford at present.

The uninterrupted periods of quiet which are prerequisites to an atmosphere of research.

Nearness to the plants under observation.

Possibility of spending easily, and without unusual effort, the early mornings among the plants one is studying.

A place to which to take a colleague and discuss, without fear of interruption, the problems which one is at work upon.

We are not alone enough, it seems to me, and this suggestion is made in the interests of those who crave time in which to think and be quiet.

Imagine an Experiment Station equipped with a half dozen of such laboratories—movable ones, if necessary. In early spring it would be determined where they should be placed to serve the needs of each investigator and as the spring opened, at that time when one needs to spend long days in the fields among the plots, these field laboratories

would, I venture to say, be inhabited by men doing a class of outdoor research of a better quality than is now being accomplished, working at a distance from home and office.

Given a small laboratory with simple equipment and a bed where one can sleep, and put it near the plants and let the investigator make his own simple apparatus, and I believe he can do a certain class of investigating better than he can in a four-story laboratory, no matter how expensively it is equipped with apparatus.

NITRIFICATION AND SOIL FERTILITY.

By G. S. Fraps,
State Chemist, and Chemist Texas Experiment Station.

[Paper on the above subject was presented at the meeting, but upon request of the author is withheld from publication.]

THE NITRIFYING POWERS OF SOILS AS INDICES TO THEIR FERTILITY.

By Chas. B. Lipman,
University of California.

No one appreciates more profoundly than I do the danger which lurks in an attempt to account for soil fertility by any one of the conditions in the soil necessary to the welfare of plants. Nevertheless, everyone who has given the subject the thought it deserves must admit that one can easily become morbidly critical with regard to the acceptance of facts, an attitude which militates against scientific progress. What I have to say to you, therefore, today is in no wise intended to explain everything which puzzles us about that most complicated and elusive subject—soil fertility. I merely desire to call to your attention some facts of great interest, which I feel justified in considering likewise of very considerable practical moment. If my statements appear too broad, you will please recall my opening words.

Logical as it may seem to seek a direct correlation between a soil's power to produce nitrates for the uses of plants and its fertility, attempts have been almost wanting among investigators in soils science to draw such correlations. In the work of Stevens, Withers, et. al., at North Carolina, published in 1909, we do find some attempt in that direction, and it was indeed demonstrated by those investigators that distinctly more good soils were possessed of a good nitrifying efficiency than poor soils. The question there which still remains open is, are we dealing with cause or effect in such a manifestation? Likewise, Ehrenberg, in earlier investigations,[1] hinted at the close relationship obtaining between a soil's nitrifying power and its fertility. In a recent bulletin of the Cornell Agricultural Experiment Station, Lyon, Bizzell and Conn give an account of a study made by them of different portions of an experimental field which, while appearing to have the same soil, showed different yielding powers. Briefly summed up, their studies seem to point to the difference in the nitri-

fying power of those soils as the most significant difference between them, while minor differences are noted in chemical composition and structure of the soils. They do not, it appears to me, however, emphasize their results sufficiently, and one gathers only inferentially that they would correlate differences in productivity of such soils with differences in nitrifying power.

The most striking and only direct published statement which has yet come to my notice on the subject under consideration is that by Vogel, of Bromberg. Vogel found a direct correlation between productivity and the nitrifying powers of soils producing different crops. The yield on those soils in the field ran parallel with the soil's power to make nitrogen (in the form of nitrates) available to plants growing thereon. Indeed, Vogel has stated as a result of his investigations that, to quote his own words, "in the large, the nitrifying power of a soil gives us a useful explanation of its state of fertility and simultaneously also valuable indications of the effect on soils and plants of different nitrogen fertilizers."

In a series of researches on different phases of the subject of the nitrifying powers of soils, we have been able at the California Agricultural Experiment Station, to correlate definitely differences in productive power of soils with similar differences in their nitrifying powers. I shall attempt to describe to you briefly the general nature of the results obtained.

Dr. T. F. Hunt called my attention last spring to a condition existing in the grain fields of this State, similar to that which he had noted previously in the grain fields of the East. From these latter observations, indeed, the researches of Lyon, et al., above cited, were an indirect result. The condition was something which nearly all acquainted with grain fields had probably noticed before but paid little attention to. It was a peculiar spotted condition in the grain field in which little clumps of tall, vigorous-looking plants would stand out from the balance of the field, which was covered largely by small and not very vigorous plants. These clumps of good grain would at times be only a few

inches in diameter and again might be twenty, thirty, or more feet across.

One grain field in the San Joaquin Valley, which we particularly investigated, did not allow of the explanation of the condition named through difference in type of soil because the field was situated on the floor of the broad valley named, in a position in which every indication as to the formation of that particular soil pointed to uniformity in type on the particular field then examined. As a matter of fact, a physical examination of the soil in the good and bad spots of the grain field showed very slight differences, if any. Borings were made and samples collected from the center of a little clump of grain and from a little spot two or three feet away where the much smaller barley plants were growing. The soil samples were taken at depths of six to eight inches and at fourteen inches, and were then sent to the laboratory for examination. The type of soil was determined to be a silt loam. We found by a chemical analysis of these soils by the Hilgard acid extraction method, that some differences of a chemical nature did obtain between these two soils, but that these differences were not always in one direction, and could not justifiably be correlated with the marked differences observed in the growth of plants on the two soils. On determining the citric acid soluble plant food, however, we found differences uniformly in favor of the good barley soil of about .003 of one percent. phosphoric acid and potash.

The most striking differences, however, were found in the nitrifying power of those soils, the good barley soil showing approximately ten times the nitrifying efficiency of the poor barley soil. From a determination of further characteristics of these soils, such as the water-holding power, and other physical characteristics, we could not justifiably conclude anything else by taking all the data together than that the difference in the nitrifying power of the two soils was the most significant difference found, thus confirming a similar finding above cited from work of Lyon and his co-workers. We found in addition, however, a difference as just remarked which should be given some weight, we

believe, if not equal weight, with the difference in nitrifying power, and that is the difference with respect to citric acid soluble phosphoric acid and potash.

The very interesting results just cited led us to attempt to confirm in a totally different type of soil the results obtained in the San Joaquin barley field. We, therefore, had collected from a barley field on the grounds of the Napa State Hospital some samples of soil that came from similar spots or clumps of good barley and from the surrounding poor barley. The soil type in this case was a humus loam, being well supplied with organic matter, while the other type of soil was very deficient. A complete chemical examination by the method used on the other soils showed not even the irregular differences obtained with the latter. The analysis of the two soils from the good and poor barley spots, respectively, was within ordinary limits of error, exactly the same. No difference was noted in the physical characters of the two soils. The only significant differences were, as in the case of the preceding soils, in available plant food as determined by the Dyer citric acid method and in nitrifying efficiency.

The nitrifying power of the good soil was six to eight times as great as that of the poor soil. Thus we find in the two totally different types of soil that a strikingly similar condition obtains with respect to productivity of the barley, and this similarity lies in the fact that there are evidently small spots, or portions, of soil in each case, which produce excellently, whereas the balance of the land produces poorly. The significant differences we find to be concerned with the nitrifying power and the available plant food supply, the first factor being the most significant, but not independent of the other. Our results are, therefore, not only strictly in harmony with those of Vogel, above cited, but also with those of Lyon.

The explanation of this condition in the barley fields is, I believe, to be made in one of three ways. A different cause for the condition will probably obtain in different fields. On grain fields which have often been pasture lands, we may expect that animal droppings through increas-

ing bacterial activity by the fermentation of the organic matter and the slight addition of soluble salts, has intensified the nitrifying power so that it would go on at least for sometime with the momentum thus gained at an increased rate in the spots where the droppings fell.

Another cause would probably be the addition of soluble phosphates and also of easily nitrifiable nitrogen from the urine of animals deposited in such spots, and carrying out effects similar in character to those induced by the droppings.

A third possible cause under California conditions, of such differences within any given type of soil in nitrifying power and in a minor way in available plant food, is to be found in the practice followed in some of our grain lands of burning the straw of the grain in small piles over the field. This will, of course, add a considerable quantity of potassium and magnesium phosphates and also of calcium carbonate and other salts to the soil, all of which would not only as the rains fell become active stimulants to bacterial development, but would themselves serve as an accretion to the soil's available plant food supply.

Whatever be the explanation, and any or all of these conditions may explain these striking differences in nitrifying power between certain spots in a given type of soil, it appears true that as was pointed out very cogently by Vogel, there is a direct relationship between the nitrifying powers of soil and their productive powers. Whether we consider this nitrifying power merely as another expression of the available nitrogen supply or in a broader sense the available plant food supply, or not, is of small moment in this connection.

Again recalling to your minds my opening remarks, I want to state without any attempt at explaining all soil troubles by their poverty in nitrifying power, that I believe that a soil's nitrifying power, whether it be the cause or effect, is one of the prime factors in determining a soil's power to produce. Naturally the question arises as to how this nitrifying efficiency or nitrifying power is to be determined. We find, for example, that it varies with the type

of organic matter supplied very markedly and have completed a great deal of work along this line which is soon to appear in print which we believe from the fertilizer standpoint, will be of very great practical significance. But if we find that with any given nitrogenous materials one soil is far superior to another in its nitrifying efficiency, then we have compared them on the same basis and that should be a fair criterion in the direction of available nitrogen supply, and hence of their productivity as above connected with it.

It is impossible, of course, in this brief paper to go into a detailed discussion of many of the factors which enter into the theoretical phases of this question, and I must leave them for other more carefully discussed statements later. I desire to call your attention, however, to the fact that the experiments above discussed, which we have carried out, and those experiments which are above cited that others have carried out, on the significance of the nitrifying power in relation to productive capacity of a soil, are not the only facts which we have in support of the thesis which I have above promulgated. The question is a far larger one than merely that of the supply of available nitrogen to grain. It is connected, I believe, and I beg you to accept this theory for whatever it is worth, with the balanced nature of the soil solution as a medium of root development and therefore may affect a large variety of crops similarly to the annual crops above discussed. It is my opinion, and I am in possession of many facts and experimental data which I cannot give you here in support thereof, that many so-called physiological diseases of plants, such as the mottled leaf of citrus trees and the die-back of the same trees, such troubles as the little-leaf of the vine and of deciduous trees, will all ultimately come to be connected with a paucity of available nitrogen in the soils on which such suffering plants are growing. We have correlated in dozens of cases poor nitrifying power of soils with some of these so-called physiological troubles of trees and vines.

As before stated, it would seem to be not precisely pertinent in this connection to discuss whether or not this poor

nitrifying power is cause or effect in such cases. Suffice it to say that in various ways the nitrifying power in such abnormal soils may be altered as we have proven to our satisfaction, and with such alteration the condition of the trees may be very much improved. Experiments on this subject are now in operation in the field, the greenhouse, and the laboratory, and we hope to discover as a result a leading relationship between bacterial activity in the soil and its fertility which may stand among the most prominent regulating factors of its productive capacity.

THE PIGMENT OF AZOTOBACTER CHROOCOCCUM.

By W. G. Sackett,
Colorado Experiment Station.

For the past four years, the publications* from the Colorado Experiment Station have made frequent reference to certain brown spots on the surface of the soil which have been observed to occur in some of the most valuable agricultural and orchard sections of the State. In color, these areas vary all the way from the reddish-brown of a finished pine knot to a dark chocolate brown or the blackish-brown of crude oil. Were it not for the extent of the larger formations, one might easily believe that barrels of oil had been emptied upon the ground, and, in fact, in the orchards where the spots are more limited in size and where oil pots have been used for heating, it is difficult to distinguish them from patches where oil has been spilled. The peculiar color of these areas gives them a wet appearance, but as a rule we find just the opposite condition prevailing, a hard, dry crust on the surface, beneath which the soil is quite mealy or ashy in character. The discoloration is not confined to cultivated land, but may extend for miles in more or less broken stretches along the adjacent public highways. A moist ditch bank or the side of an irrigating furrow appears to offer the optimum conditions for the development of the brown color; on the latter, about two days after the irrigating water has been turned out, there develops a broad brown band lengthwise of the furrow extending from a little above the water line to the crest of the ridge. The spots vary in size from patches the size of a man's hand to tracts of eight and ten acres. They do not necessarily develop simultaneously in a given district, but one year they may show up in one part and the next year in another; once present, they are not necessarily always present. Although some of the areas involved now embrace several acres, they have not always

* Colorado Experiment Station, Bulletins 155, 160, 178, 179, 183, 184, 186, 193, 196.

been this extensive, since this condition usually comes about gradually rather than by the sudden development of the brown color over an extensive area. We have a number of cases under observation at the present time where there was not a sign of a brown spot six years ago, yet today, on some of these localities, several acres are affected, while in others only spots, less than a tenth of an acre, have developed. In such cases as these we have been able to watch the growth and development of the brown patches; beginning with a spot, possibly 100 feet in diameter as a focal center, it has spread gradually month by month and year after year, frequently coalescing with neighboring spots, until what was once a limited area, now includes a number of acres. Old spots are increasing in size today, and new spots are making their appearance in regions where they have never been seen before. Manifestly, then, these spots have not existed always, and, moreover, many are in the process of formation at the present time.

About nine years ago, the first complaints were received of injury to crops by the brown spots. Not only would nothing grow in these areas, but also positive harm resulted to trees and crops that had been planted on such tracts previous to their developing the trouble. It was about this time that Dr. Headden began his study of the soils in these localities, the results of which have shown, first, that the brown spots are very rich in nitrates, and, second, that the excessive nitrates are responsible for the death of the trees and crops.

I need not refer at this time to the thorough and extensive investigation of the ground waters and irrigating waters of these and others regions which Dr. Headden has made with reference to their nitrate content in relation of the shales and sandstones, except to state, upon his authority, that they contain only traces of nitrate. An exception to this statement is to be made for those waters which flow under niter areas. All of his work has been published* and is accessible to those who would read and be informed.

* Colorado Experiment Station, Bulletins 72, 82, 83; American Journal of Science.

Satisfied beyond a reasonable doubt that the high nitrates in the brown spots are not of marine origin, the results of nitrification in ages past, and that they are not being transported as such by the ground waters, but that they are being formed *in situ* at the present time, Dr. Headden suggested a bacteriological study of these soils to the writer.

Accordingly, some four years ago, this work was taken up, beginning with an investigation of the nitrogen fixing organisms present in both our normal and incipient niter soils. It is not our purpose at this time to go into the details of this study, except to state that in both types of soils we find *Azotobacter chroococcum* very abundant. Lest this statement be misunderstood, I may qualify it a little further by saying that these forms are absent for the most part in the interior of the brown spots down to a depth of ten to twelve inches, below which they have been found to be again present. There seems to be little doubt in such cases but that the increasing concentration of the salts in the surface layers is responsible for their death and disappearance, since at the margin of the brown areas and immediately outside of them the Azotobacter cells are very plentiful. Furthermore, we have observed repeatedly that as the spots grow larger and encroach upon soil where Azotobacter has been abundant, they gradually disappear and finally are annihilated.

Coming now to the question of the pigment of Azotobacter chroococcum, we found among our first pure culture isolations several colorless strains, a few that produced a light brown color at times, and one that gave an intense dark chocolate brown pigment on mannite agar. This brown color was so strikingly similar to the brown spots in the field that one could not help speculating as to a possible relation between the two. Cultures of this strain grown upon sterilized quartz sand, sterilized sand, and sterilized soil resembled the field samples perfectly. However, when the colorless strains were employed in the innoculation of sterilized quartz and sterilized sand no pigment was pro-

duced, but when grown upon the soil from which it was originally isolated, abundant pigmentation followed. Evidently there was some relation between the elements of this soil, an incipient niter soil, and the pigment forming properties of the microorganism.

Following this clue, a number of synthetic agars were prepared whose composition was based upon the soluble salts in a certain soil which was very brown. The analysis follows:

Water soluble amounted to 2.97 percent. of the air-dried soil.

$CaSO_4$	15.902	$NaCl$	34.145
$MgSO_4$	2.942	$NaNO_3$	22.781
K_2SO_4	3.387	Silicic acid	.252
Na_2SO_4	15.264	Loss	.471
Na_2CO_3	4.813		

Eight agars were prepared, each differing from the others in the absence of one of the above-mentioned salts. Mannite was used throughout at the rate of 1.5 percent. to furnish carbon, except in a check series on the mannite. Streak cultures were made on each agar from four different strains: A stock culture of A. chroococcum, obtained from Dr. Beijerinck, Delft, Holland, a dark brown strain No. 3, one that produced a feeble pigment at one time but lost it later (No. 93), and one that had shown no tendency at any time to produce pigment beyond a dirty white (No. 8).

Good growth was obtained upon all of the agars save the one lacking mannite, and here it was difficult to say whether there was any actual growth or whether it was just the line of the original transfer. The results of the pigment formation were very sharp; a decided dark brown color was obtained with all four of the cultures on all of the agars except that lacking nitrates. Here with the stock culture of A. chroococcum and No. 3, the dark brown strain, there was not a trace of brown, but only a dirty white. In culture No. 8 (colorless) there was a small amount of brown pigment at the bottom of the streak and

in the water of condensation, the remainder of the growth being dirty white; culture No. 93 (colorless now, but formerly with some pigment) contained a few brownish specks in the water of condensation, which, under ordinary circumstances, would have been overlooked; the streak proper was dirty white. Without exception, all of the cultures produced chocolate-brown to black pigments on the different agars except those lacking mannite and sodium nitrate. I feel that we are not begging the question when we state that the reason we obtained no pigment in the absence of mannite was because we had no growth. To me, it is perfectly clear from the results of this series, that given a source of energy, the nitrate is the limiting factor in the formation of the dark brown color. I am not prepared to say, at present, whether the nitrate acts as a stimulant to growth, pure and simple, or whether it exercises an oxidizing function on certain bacterial products. The results of this experiment with the two colorless strains have been produced in color, a copy of which I am submitting for your examination.

To determine whether the amount of nitrate present bears any relation to the intensity of the brown color exhibited by cultures, we prepared another series of agars. Glucose was substituted for mannite, since two of our cultures produced pigment on the standard mannite agar, and it was determined experimentally that if this substitution was made practically no color resulted with any of the cultures. By doing this, all brown pigment-producing factors were eliminated, and we had a medium that would support growth and to which the limit compound could be added. A stock glucose agar was made up containing two percent. glucose and two percent. agar, in tap water. To different lots of this medium, sufficient sodium nitrate was added to give a sodium nitrate content of 0.0, .01, .03, .05, .08, 0.1, 0.3, and 0.5 percent. respectively. Streak inoculations were made with seven of our stock cultures upon these nitrate agars, and after 14 days we secured a beautiful series of pigments ranging a light brown through a dark chocolate-brown to black, depending upon the quan-

tity of nitrate present. No pigment whatever was produced in the control tubes with no nitrate. The maximum intensity of color was reached in the tubes containing .05 to .08 percent., beyond which there was an almost uniformly dark chocolate-brown or black pigment. Colored plate II shows such a series made from culture No. 8, a colorless strain when grown on mannite agar. After one has seen this experiment, there is little room for questioning the fact that given a supply of carbon, sodium nitrate, of and by itself, can cause even the colorless strains of A. chroococcum to produce a chocolate-brown to black pigment. This observation is further borne out by the observations of Beijerinck,[1] who has shown that "Pigment formation can be observed in pure cultures if the mannite is replaced by dextrose and nitrate is added in minimum quantities."

In the application of these results to field conditions, we have a very tenable explanation of the brown color of the soil. It has been shown that these soils are abundantly stocked with A. chroococcum, and in the presence of the large amounts of nitrate which they carry the inevitable consequence must be the production of an intensely brown pigment, which has brought the spots to our attention.

In 1904, Heinze[2] expressed the view that possiby the dark color of soil was due in a degree to the pigment of A. chroococcum. Omeliansky and Ssewerowa[3] (pronounced Chayerova) are of the opinion that, while it would be a mistake to attribute the dark color of soils to this cause altogether, one has no right to deny the possibility of its occurrence. They have shown experimentally that a brown pigment is produced by Azotobacter in a medium containing chalk and hydrolized starch, both of which are present in soils as $CaCO_3$ and as decomposed plant tissue respectively. Therefore, they conclude that, "The part which

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[1] Beijernick, Cent. f. Bakt., abt. II, Bd. 7, p. 561, 1901.

[2] Heinze, Cent. f. Bakt., abt. II, Bd. 12, p. 357; Bd. 16, p. 341, 1906.

[3] Omeliansky and Ssewerowa, Cent. f. Bakt., abt. II, Bd. 29, p. 649. 1911.

Azotobacter plays in the dark color of the soil is not to be overlooked."

Before leaving this aspect of the subject, let it be understood clearly and emphatically that we have no intention of using either the nitrates or the nitrogen fixing flora of our soils to explain every brown spot or similar discoloration that may be found. We are aware that there are at least two other recognized agents that may be responsible for a similar condition. I refer to the well-known Black Alkali of the southwest in which sodium carbonate is the active principle in bringing the soil humus into solution, which solution, being highly colored, may give the surface a dark appearance. Again, there are some soils which contain sufficient quantities of calcium chloride to absorb enough moisture to impart a dark color to the soil. I have Dr. Headden's statement that none of the soils with which we are concerned contain enough of either sodium carbonate or calcium chloride to account for this phenomenon.

After establishing a relation between nitrates and pigment formation, we were interested in learning whether this property was confined to nitric nitrogen alone, or whether it was shared by other forms of nitrogen as well. To this end, streak inoculations were made on stock glucose agar containing proteid nitrogen as peptone, amido nitrogen as asparagin, ammonia nitrogen as ammonium chloride and ammonium sulphate, and nitrite nitrogen as sodium nitrite. After eighteen days none of the cultures had produced any pigment whatever with any form of nitrogen except the nitrite. Here, three of the four strains employed gave brown to chocolate pigments. Controls on glucose agar without nitrogen produced no color, while a check set containing nitrate exhibited an intense brownish-black with all cultures.

Leaving our study of the development of pigment in the test tube culture at this point, we shall turn our attention next to an entirely different phase of the subject.

Does the brown color, as it develops on the surface of the soil and on the sides of the ditch banks and irrigating furrows, necessarily indicate that the germs themselves are

present on the surface? May it not be possible that this discoloration is merely a stain due wholly or in part to a solution of the bacterial pigment, assuming, of course, that the coloring matter is soluble in the soil water and that it is carried to the surface and there concentrated, the micro-organisms themselves being somewhat removed from the stained region? Experimental evidence leads us to believe that in many cases where the color is very dark, the latter supposition is not untenable. There are undoubtedly cases where both conditions exist. During the routine of chemical analysis, we have observed that the soil extracts made from brown spots are invariably highly colored, varying from a straw yellow to a molasses brown, and when these extracts are evaporated to dryness we have a picture not unlike the brown pigment. In fact, these highly-colored extracts were so common and became so troublesome that Dr. Headden abandoned the phenoldisulphonic acid colorimetric method for nitrates in brown soils wholly on this account.

Beijerinck, Omeliansky and Ssewerowa have found that this pigment is insoluble in the ordinary solvents such as water, alcohol, chloroform, ether and carbon disulphid, but that under the action of alkalies it goes into solution, thereby changing itself chemically.

So far as we know, our brown soil extracts are alkaline, but in order to learn just what influence the different salts in our soils might exert upon the solution of the pigment, we have made a special study of this subject. Where salts have been employed in the experiment, we have used 10 percent. solutions in distilled water; alcohol of the strength of 95 percent.; ether, chloroform, carbon disulphid, full strength, and all acids as normal solutions.

The dark brown bacterial growth from flask cultures on mannite agar was treated with the various solutions, hot and cold, for a period of two weeks, and at the end of this time the degree of color imparted to the clarified solution was taken as an index of the solvent action of the given compound. A preliminary tentative report of the results follows: Insoluble in distilled water, alcohol, chloro-

form, carbon disulphid, potassium chlorid, sodium dithionate, sodium hyposulphite, sodium chlorid, pottassium chlorate, potassium nitrate, mono basic potassium phosphate, mono basic sodium phosphate, ammonium chlorid, ammonium hydroxide, ammonium sulphate, ammonium nitrate, ammonium oxalate, potassium aluminum sulphate, magnesium sulphate, magnesium chlorid, calcium chlorid, calcium nitrate, sulphuric acid, hydrochloric acid, boric acid, citric acid, malic acid, and oxalic acid.

Slightly soluble in: Warm ether, sodium sulphate, sodium sulphite, sodium acetate, di-basic sodium phospate, di-basic potassium phosphate, potassium bromide, potassium sulphate, potassium iodide, potassium acetate, calcium hydroxide, calcium superphosphate, magnesium nitrate, acetic acid, lactic acid, propionic acid, tartaric acid.

Very soluble in: Tri-basic potassium phosphate, tri-basic sodium phosphate, sodium hydroxide, potassium hydroxide, potassium carbonate, sodium carbonate.

Inasmuch as many of these compounds are present in our soils, we feel reasonably safe in stating at this time that the brown color of our soil extracts is due wholly or in part to the solution of the pigment of A. chroococcum by the soil waters.

VARIATION IN PURE LINES OF WINTER WHEAT.

By C. G. Williams,
Ohio Experiment Station.

Is there any variation, which is heritable, in pure line selections of winter wheat?

The Ohio Station began a series of experiments in 1907 and 1908 in the study of variation with respect to four characters, viz., length of head, size of kernel, protein content, and tillering.

1. **Variation in Length of Head.**—In September, 1908, head number 8071, Fultz wheat, 3.6 inches in length, was planted. There were grown and harvested from this original head 26 plants bearing 201 heads. The average length of the 201 heads was 3.2 inches. The longest head was 4.6 inches; the shortest, 2.5 inches.

The 201 heads were divided into three classes: the 10 longest heads in one; the 10 shortest heads in another, and the balance forming a so-called normal class. The 10 longest and 10 shortest were planted on alternate rows, a head to a row. Ten rows were also planted from the normal strain, a composite sample being made up by taking one spikelet from each head.

The average length of the 10 long heads planted in 1909 was 4.25 inches. Of the 10 short heads, 2.6 inches. Of the normal heads, 3.17 inches. The average length of head of the crop grown from the three strains is recorded in column 4 of table 1. It will be noted that the average length of head is slightly greater in the short-head strain than in the long; and, further, that the extremes in length are slightly wider in the short-head strain.

In continuing the work from year to year the long-head strain has been perpetuated by the selection of the 10 longest heads produced each year, for planting, and the short-head strain by the 10 shortest heads. The result of each year's work is given in table 1.

In only one season—that of the planting of 1912—has the crop produced from the long heads averaged as long heads as the short-head strain, and this is reversed the following season.

It will be noted that insofar as averages are concerned there is very little variation in the progeny of the two contrasted strains. Little variation from season to season, and still less variation when the fourth generation is compared with the first. The fourth generation of the two strains is closer together than the first, while the average of the averages differs by only one hundredth of an inch.

There is, therefore, to date no indication of any variation in length of head in pure lines which is heritable.

2. **Variation in Size of Kernel.**—In 1908, 10 heads of Fultz wheat were selected for a study of variation in pure lines with respect to size of kernel. Two rows were planted from each head. One with the 10 largest, the other with the 10 smallest kernels. Shriveled kernels were rejected. The average weight per kernel of the seed used the first year is recorded in column 2. The comparative size of kernels in the crop grown from the above seed was determined by counting the number of kernels in 10 grams. The results are given in column 3, the yearly average of the 10 pure lines appearing at the bottom of the table.

Each pure line has been continued in two strains, (*a*) the large, and (*b*) the small-kernel strain. Since the first year 100 kernels have been selected from each strain for planting. The largest kernels from strain *a*, and the smallest kernels from strain *b*. The character of the seed used each year for the five years the test has been conducted is shown in columns 2, 4, 6, 8 and 10, and the character of the crop in columns 3, 5, 7, 9 and 11.

Comparing the yearly averages, it will be noted that in the first crop harvested the 10 large-kernel strains average 372 kernels per 10 grams, while the 10 small-kernel strains average 369 kernels, the latter producing slightly larger kernels. In the second crops (column 5) the result is similar. In the third it is reversed, and continues thus in the fourth and fifth.

Comparing the crop of the fifth generation with the first (column 11 with 3) in 6 of the 10 pure lines, selection for large kernels has resulted in slightly larger kernels, while in 4 pure lines it has resulted in smaller kernels.

Similarly, the selection for small kernels has resulted in larger kernels in 5 of the 10 pure lines and in smaller kernels in the case of 5 pure lines.

In 3 of the pure lines (Nos. 3, 6 and 10) despite the selection for small kernels, the fifth generation has resulted in larger kernels than where the selection had been made for large kernels.

Furthermore, in only 2 of the 10 pure lines (Nos. 5 and 7) has the variation been what would normally be expected if it were heritable, viz., the large-kernel strain increasing in size and the small-kernel strain decreasing in size.

3. **Variation in Protein Content.**—In 1907 the Ohio Station began the study of variation in pure lines of wheat with respect to protein content. Two pure lines were used. One of the Fultz variety, the original head of which analyzed 12.92 percent. protein, and one of Poole, analyzing 11.87 percent. protein.

Of the first crop (1908) 100 normal heads of each pure line were analyzed for protein content. In determining the percent. of protein the kernels on one side of the rachis were used, those on the other being saved for possible planting. From the 10 heads of each pure line analyzed, two strains were started, one made up of the 100 heads having the highest, the other of the 10 heads having the lowest percent. of protein. These heads were planted in rows alternately, a high and a low percent. The head having the highest percent. of protein in the Fultz pure line analyzed 20.13 percent., and the average of the 10 highest was 16.81 percent., as recorded in column 2. The head having the lowest percent. of protein analyzed 10.38 percent., and the average of the 10 lowest was 12.44 percent.

A so-called normal strain, made up of the 80 intermediate heads, has been carried along as a check.

Ten good heads were selected from each row of the two strains in both pure lines, making 100 heads for each strain. These heads were analyzed and the 10 heads highest in protein in each high-protein strain, together with the 10 heads lowest in protein in each low-protein strain, were used as above to continue the strain. The average protein content of the seed used and the crop harvested for the five

years, during which the test has been conducted, is given in table III.

Comparing the differences in percent. of protein in the Fultz pure line each generation, it will be noted that it was slightly greater in the first generation than after five years of continuous selection in opposite directions. While there is a little gain in the Poole pure line, it would appear that the chances for increasing the protein content of wheat by selection within a pure line are exceeding small, if not altogether worthless.

In all of these pure lines investigations the wheat crop of 1911 and 1912 was lost, owing to necessarily late planting and the exceptionally severe winter. Seed had been reserved of each strain, however, so that nothing was lost save one year's work.

TABLE I.—VARIATION IN A PURE LINE OF WHEAT WITH RESPECT TO LENGTH OF HEAD.

1	2	3	4	5	6
Year planted.	Strain.	Average length of heads planted. (Ins.)	Average length of heads in crop grown. (Ins.)	Longest head. (Ins.)	Shortest head. (Ins.)
1908		3.60*	3.20	4.6	2.5
1909	Long	4.25	3.02	4.9	2.3
	Short	2.60	3.07	5.0	2.2
	Normal	3.17	3.08	5.2	2.4
1910	Long	4.53	4.05	6.1	1.9
	Short	2.50	4.11	5.6	1.7
	Normal	3.10	4.07	5.6	1.8
1912	Long	5.45	2.80	4.8	1.3
	Short	2.85	2.71	4.1	1.1
	Normal	4.10	2.67	4.4	0.9
1913	Long	4.10	3.58	5.5	1.8
	Short	2.23	3.60	5.1	1.8
	Normal	2.70	3.52	5.4	1.9
Average	Long	4.58	3.36¼		
	Short	2.54	3.37¼		

* The original head.

TABLE II.—VARIATION IN PURE LINES OF WHEAT WITH RESPECT TO SIZE OF KERNEL.

	1908–09		1909–10		1910–11		1912–13		1913–14			Five year av.	
1	2	3	4	5	6	7	8	9	10	11	12	13	14
Strain.	Average weight per kernel of seed used. (Grams)	No. of kernels in 10 grams of crop harvested.	Average weight per kernel of seed used. (Grams)	No. of kernels in 10 grams of crop harvested.	Average weight per kernel of seed used. (Grams)	No. of kernels in 10 grams of crop harvested.	Average weight per kernel of seed used. (Grams)	No. of kernels in 10 grams of crop harvested.	Average weight per kernel of seed used. (Grams)	No. of kernels in 10 grams of crop harvested.	Comparing the fifth generation with the first.	Average weight per kernel of seed used. Grams.	No. of kernels in 10 grams of crop harvested.
8001 a	.0342	356	.0438	362	.0412	264	.0498	310	.0380	298	a Increase	.0414	318
8001 b	.0229	351	.0143	346	.0175	292	.0192	309	.0220	320	b Increase	.0192	324
8002 a	.0364	398	.0396	402	.0375	290	.0446	337	.0380	286	a Increase	.0392	343
8002 b	.0254	438	.0205	439	.0212	289	.0199	315	.0210	357	b Increase	.0216	368
8003 a	.0362	338	.0409	382	.0375	284	.0491	306	.0400	369	a Decrease	.0407	336
8003 b	.0223	340	.0197	331	.0162	289	.0216	322	.0240	358	b Decrease	.0208	328
8004 a	.0474	394	.0398	396	.0337	304	.0435	340	.0390	328	a Increase	.0407	352
8004 b	.0321	384	.0138	384	.0137	284	.0203	342	.0210	365	b Increase	.0202	352
8005 a	.0396	312	.0500	348	.0487	247	.0532	291	.0460	306	a Increase	.0475	301
8005 b	.0239	279	.0196	325	.0150	263	.0250	302	.0240	471	b Decrease	.0215	328
8006 a	.0350	352	.0422	369	.0375	289	.0464	313	.0400	446	a Decrease	.0402	354
8006 b	.0232	360	.0157	367	.0175	312	.0202	311	.0230	382	b Decrease	.0199	346
8007 a	.0355	393	.0477	322	.0450	253	.0496	321	.0410	316	a Increase	.0418	321
8007 b	.0240	306	.0158	317	.0137	279	.0228	346	.0200	353	b Decrease	.0193	320
8008 a	.0296	480	.0356	391	.0387	301	.0468	336	.0390	428	a Increase	.0379	387
8008 b	.0159	513	.0152	344	.0125	334	.0191	362	.0210	444	b Increase	.0167	399
8009 a	.0393	342	.0434	277	.0437	281	.0466	315	.0410	398	a Decrease	.0428	323
8009 b	.0264	337	.0159	284	.0187	272	.0229	311	.0230	414	b Decrease	.0214	324
8010 a	.0354	353	.0433	295	.0450	279	.0472	319	.0400	358	a Decrease	.0422	321
8010 b	.0212	380	.0173	300	.0137	307	.0215	323	.0220	313	b Increase	.0191	325
Av. a	.0369	372	.0426	354	.0480	279	.0477	319	.0402	353		.0414	336
Av. b	.0237	369	.0168	344	.0160	292	.0212	324	.0221	378		.0200	341

TABLE III.—VARIATION IN PURE LINES OF WHEAT WITH RESPECT TO PROTEIN CONTENT.

	1908–'09		1909–'10		1910–'11		1912–'13		1913–'14		Five Year average.	
1	2	3	4	5	6	7	8	9	10	11	12	13
Strain.	Seed used.	Crop harvested.	Seed used.	Crop harvested.	Seed used.	Crop harvested.	Seed used.	Crop harvested.	Seed used.	Crop harvested.	Seed used.	Crop harvested.
Fultz, High	16.81	12.53	15.26	14.35	19.17	16.82	18.17	14.54	17.73	13.02	17.43	14.25
Fultz, Low	12.44	11.95	9.95	14.56	11.64	16.61	14.34	13.63	11.67	12.46	12.01	13.84
Difference between High and Low		+.58		—.21		+.21		+.91		+.56		+.41
Fultz, Normal	14.41	11.91	11.91	13.76	13.76	15.97	15.97	13 68	13.68	12.55	13.95	13.57
Poole, High	17.21	12.52	15.55	14.26	20.33	18.32	19.87	13.32	16.74	14.10	17.94	14.50
Poole, Low	12.08	12.63	10.24	14.25	11.22	18.01	16.18	12.87	10.40	13.52	12.02	14.26
Difference between High and Low		—.11		+.01		+.31		+.45		+.58		+.24
Poole, Normal	15.13	13.51	13.51	14.42	14.42	17.85	17.85	13.67	13.67	16.52	14.92	15.19

NOTES ON THE PROGRESS OF ECONOMIC ENTOMOLOGY.

By L. O. Howard,
United States Department of Agriculture.

When General W. G. Le Duc took office as United States Commissioner of Agriculture, July 1, 1877, just 37 years ago, the annual appropriation to the Department was $174,-086.96, and there were 77 employees. The Department was in the main a statistical, correspondence and seed distribution bureau. Virtually no research was being carried on. The entomologist, with one assistant only, was engaged almost entirely in the general museum work of the Department. In the country at large there were no State experiment stations, and but three State entomologists—Riley in Missouri, Thomas in Illinois, and Fitch in New York, the latter past his days of work. There were practically no teachers of entomology. Hagen had a few students at Harvard, but did not touch on the economic aspects of the science; Comstock was just beginning to teach at Cornell; Burrill was giving a few lectures out west, and Fernald was soon to begin at Orono.

When Doctor Houston took office as Secretary of Agriculture July 1, 1913, the appropriation to the Department was practically eighteen millions of dollars ($17,986,945) and there were 14,478 employees. The Department had become the greatest research organization in the world. The appropriations for entomology were $742,210. The entomological service had become a large bureau with about six hundred employees, of whom more than two hundred were scientifically trained experts. Every State had its competent agricultural experiment station, with a force of entomologists. Practically every State had also its agricultural college with teaching in general and economic entomology. In California there were even county entomologists, and Boston and Philadelphia had their city entomologists.

In a way the wonderful general increase in agricultural research and agricultural endeavor had carried economic entomology along with it. The passage of the Hatch Act

and the consequent founding of the State experiment stations were responsible at once for a great increase in the number of working entomologists, while in immediate succession the introduction of the gypsy moth into New England, the appearance of the San José scale in the east, the march of the cotton boll weevil in the southern States, and the discovery of the carriage of disease to man and animals by insects, have made the importance of entomological work greater and greater. It is no wonder that the country rose to these emergencies; that Congress and the legislatures have given large appropriations, and that by virtue of the successful investigations of our rapidly increasing group of entomological workers the United States has already gained a commanding position among the nations of the world in this branch of applied science.

It is not generally realized, except among a limited group of teachers, just how this extraordinary advance in a few years has influenced the number of students seeking information on economic entomology at the different institutions, nor just in what way it has influenced the character of the instruction. The present year in six of the leading agricultural colleges, where most attention is paid to economic entomology, there are 1,531 students in entomology, and 51 teachers. These institutions are the Ohio State University, the University of California, Cornell University, the Massachusetts Agricultural College, the University of Illinois, and the University of Nebraska. These six I have chosen because they have the largest number of students in this line, but in every agricultural college in the country sound teaching in going on. In the south, at Clemson College, S. C., at Auburn, Ala., at Baton Rouge, La., and at College Station, Texas, and elsewhere, there are numbers of students and excellent courses. In the northwest it is the same. At Wisconsin there are 103 students and five teachers. In the small college at Bozeman, Mont., there are 27 students. The men in charge of these different departments are all practical men. Most of them, in fact I think all of them, are primarily economic workers. Many of them have been and are still connected with the State agri-

cultural experiment stations. Some of them have been connected with the force of the Bureau of Entomology of the U. S. Department of Agriculture. Several of them are still collaborators of the Bureau. It follows that these men know the economic problems which confront us and that they have a broad knowledge of what is going on, not only in this country but in other countries; and it follows further that the instruction which they give is that best designed to bring practical results. Moreover, they are a harmonious and co-operative body of men. They all belong to the Association of Economic Entomologists, which, through its annual meetings and its standing committees, is constantly facilitating such co-operation. All of these men are keen to grasp new ideas and are so non-conservative as to methods of teaching that they will at any moment introduce new features and new methods.

In its international aspects, economic entomology is developing with great rapidity and will continue to do so. The Association of Economic Entomologists early elected to its membership practically all of the official entomologists of foreign countries, which brought about a universal exchange of publications and frequent correspondence. This has led to visits to America by many foreign entomologists, and many of our own men have gone abroad, so that personal relationship has brought about friendships and mutual aid. There are constant visits to this country on the part of younger men from other countries, for study in the different lines of economic entomology, and the Imperial Bureau of Entomology of Great Britain has, with Dr. Andrew Carnegie's financial aid, founded a series of scholarships in economic entomology which brings several specially selected young Englishmen to this country each year to study in the Bureau and at the colleges and experiment stations. There are six of them in the United States at the present time. They all want to go back to take part in the war, but their government will not let them do so. All this will bring about in the near future an increase in the solidarity of interests and information and mutual helpfulness which already exists among the economic entomologists of the

whole civilized world. Each new idea is and will be almost instantly known to all and speedily tested in every climate and under all sorts of world conditions. Important parasites found in a remote region will not have to be carried immense distances in the future, but will be relayed from one country to another, a generation or so reared at each stop and then sent on.

The passage of the Federal Horticultural Law in 1912 has brought us into the closest relationship with the plant inspection services of other countries, and last year at a congress in Rome an effort was made to harmonize laws and to bring about comparatively uniform systems by the different countries. This is a movement which will gain force in the future. One of the more trivial and unconsidered aspects of the present war is its effect on inspection services. Of course, shipments of plants and plant products from the countries engaged are almost entirely at a standstill, but arrangements have been made by our authorities to accept Holland's certificates for Belgian shipments, and the other day I received a note from the French Ambassador, stating that his government had cabled him on behalf of Dr. Paul Marchal to the effect that the French inspection service will be carried on to the best of his ability under the circumstances.

How the entomological problems of the future will be met can only be guessed at, but the work of the past few years has greatly increased our belief in the necessity for the most thorough biological study of every injurious form. So many instances have occurred with species whose life history was apparently well understood and whose behavior was also thought to be known, but which have been found, under extensive study, to possess unexpected points of attack, that the importance of the closest study of every species from every point of view has become very evident. The trend is towards intensive study of every phase of the insect's existence.

Since we have built up in this country in these past twenty or thirty years such a very respectable branch of knowledge which we have termed "economic entomology" or "applied

entomology," we are naturally proud of our accomplishment and anxious to see the good work continue in the same general way and under the same name. But there is a tendency now to break into the solidarity of our branch of science and to unite us with the plant-disease people under the term "phytopathology," insofar as insects affect plant life, and with the internal parasite people, under the term "parasitology," where insects directly affect man or animals. I think that economic entomologists should resist this tendency. The term "phytopathology," in this significance, apparently originated in Germany. Perhaps for the reason that at the time there were practically no economic entomologists in Germany, there was no protest, but when the European San Jose scale scare occurred in 1898 and an inspection service was started in that country to prevent the incoming of this dreaded insect, a plant disease man was put at the head of the service, a curious anomaly which probably might not have occurred elsewhere. It is true that an entomologist was appointed under this person, but the service suffered. The term "phytopathology" should be restricted to plant diseases, and many Germans themselves believe this. A society of economic entomologists, on the plan of our own association, was founded in Germany last year, and, through its efforts and increasing importance, it is likely that the encroaching botanists will be held in check. It is perhaps of sufficient interest to state that the congress which was called at Rome last year to consider inspection services was called as a phytopathological congress, although it was distinctly understood that the function of the congress was to consider questions relating principally to the prevention of international transportation of injurious insects. The United States sent no delegate to this convention, but did send a letter urging that future congresses of the same nature should be termed congresses of economic entomology and phytopathology.

It is very obvious that plant pathology and economic entomology are unrelated in their basic principles. Their successful study requires from workers absolutely different training and wholly different technique. To combine them

into one service would be impracticable, except as units of a large agricultural institution. To combine them under one name as a branch of agricultural science is absurd.

The second term, "parasitology," has perhaps a better justification than the other, but the questions relating to the damage done by insects to man and domestic animals is competently handled by the economic entomologists familiar with the whole range of entomological activity. Why take a protozoologist or a helmintologist and make him learn all about the insects that affect animals in order to become a parasitologist, when the men who have always worked at economic entomology are handling the same questions under another term? In our entomological proceedings and in our entomological journals and our entomological reports all matters relating to insects are brought together. Why put entomological material together with a lot of plant-disease material into a publication entitled phytopathology, and why mix up a lot of entomological material with a lot of other material on worms and the like in a publication called parasitology? And after a branch of applied science has been so well grounded and so successfully carried on under a comprehensive and at the same time exact term like "economic entomology," why try to confuse matters and break into a field so well defined and so successfully organized?

Both terms have come to us from Europe, and the attempt to introduce them into this country has been made by Americans who have studied under European masters. It seems to me, however, that the term "economic entomology," or "applied entomology" is more likely to take a firmer hold in Europe than is the term "phytopathology," in this significance, to gain ground in this country, and that will mean that internationally the term "economic entomology" as applying to the whole field will be generally adopted.

That side of economic entomology which relates to the carriage of disease by insects has been aptly termed "medical entomology," and is best carried on by trained entomologists. The truth of this statement is probably self-evident, but if a convincing argument is needed it will be found in Hunter's admirable address on medical ento-

mology before the Twenty-fifth Annual Meeting of the Association of Economic Entomologists (Journal of Economic Entomology, February, 1913, pages 27 to 38). It is in this field of applied entomology that we must perhaps look for the greatest advances in coming years.

And now at the close of 1914, after considering the results already achieved, and with a knowledge of the investigations under way and of the men who are handling them, with the sound instruction which is being given in two score institutions of learning, with the hundreds upon hundreds of clever students, many of whom will make this field their life work, it is impossible to avoid the conclusion that we are carrying on and will continue to carry on a winning fight against the greatest enemies of the human race.

THE MASSACHUSETTS STATE FORESTRY WORK.

By F. W. Rane,
State Forester, Massachusetts.

It is believed that we are still woefully lacking in the United States in being unable to show more results from the practice of modern forestry. In analyzing the situation it cannot be attributed to lack of enthusiasm and willingness on the part of the men in the profession. For some reason, the owners of the larger tracts of forest lands seem interested but non-active, and real operating lumbermen change their methods relatively slowly. Public, National and State undertakings in forestry from the standpoint of constructive and business-like methods seem to be lacking in vigor. Lack of funds to do with would appear to be the trouble; but why should this be, if the investment will warrant the expenditure. I believe the greatest weakness in forestry at present is the lack of stalwart men able to convince our legislatures, business corporations and men of affairs, of the great importance of doing something on a much larger and more comprehensive scale than we have yet accomplished. Planting a thousand or more trees or thinning and practicing modern forestry methods on a five-acre tract here and there are but drops in the bucket as compared to what ought to be undertaken in forestry in our various States and throughout the nation. Had we attempted to dig the Panama Canal under the same momentum that we are practicing forestry today, it is questionable if it would ever have been completed; we, however, are allowing our lands adapted for splendid forest crops to lie idle, and, worse than that, not even forest fires are kept under control.

Up to the present time, most American foresters have looked wise, given a great deal of advice, written pamphlets and books, and kept up a very good propaganda of forestry interest, but we have still, it is believed, a great lack of results that will come only when the fundamental problems have been given deeper root.

In calling attention to the work in forestry in Massachusetts, I preface my remarks thus because it has not been a question of object lessons, examples and demonstrations to follow, but a working out of our State system by our own efforts.

Before the States began to have foresters, the United States Forest Service offered advice and assistance throughout the nation. During this time, many examinations and recommendations by experts were made for Massachusetts people, but, strange to say, when these same documents were checked up for results later, it was found scarcely anything had been accomplished. The work on behalf of the forest service was well executed and the owners were evidently interested in the beginning, but the work failed to be carried out simply because it was not followed up and kept alive by further personal contact. One thing has been conclusive thus far in our experience in Massachusetts, and that is, if anything tangible is to result in forestry work, it first must be demonstrated by technical men right in the State. Then our farmers and lumbermen know we are advocating what can be accomplished from actual experience. The more real and definite examples a State forester can have scattered about his State, the sooner will he be able to make headway toward bettering general forestry conditions. Object lessons not only educate but encourage action.

During the past eight years, year by year, through kindly consideration and definite legislation, the members of our general court enthusiastically headed by our public-spirited Governors, have given us statute after statute, until I am pleased to say I believe we now have a thoroughly well-rounded-out Massachusetts State Forest Policy. I am frank to say that I know of no State in the Union wherein the individual who cares to practice modern forestry can get more co-operation on the part of the State than in Massachusetts. While it is not the State's policy to actually give anything away, we nevertheless are so solicitous over ultimate success that we are doing everything possible to encourage our people to practice modern forestry.

I do not care to weary you by citing all of our various laws which are the foundations of our State forest policy, as they can be had in their printed form, but I do wish to point out briefly what is being done for forestry in Massachusetts.

(1) Expert forestry services are given at no expense, except travel and subsistence, to anybody in Massachusetts. Blank forms for requesting such assistance are available from the State Forester's Office, Boston.

(2) In addition to expert advice, the State Forester's Office has published for free distribution, bulletins on the subjects of chief interest.

Forest thinnings.
Reforestation and nursery work.
Mensuration of white pine.
Forest fire control and management.
The chestnut blight disease.
What is forestry.
How and when to collect white pine seed, etc.

(3) **Organization.**—The State Forester has general supervision. He is given trained assistants in the various branches represented in State work. The assistant in forest fire work is given the title of State Fire Warden. Each town and city in the State has an officer known as Forest Warden. This officer is appointed by the officials of the town or city and his appointment is subject to the approval of the State Forester. The local forest warden is clothed with enough power to get results in his jurisdiction. Some of his powers and duties are as follows:

(*a*) No warrants can be paid for fighting forest fires without his approval.

(*b*) May compel any citizen between the ages of 18 and 51 to assist in fighting forest fires or may compel the use of teams and implements of another for similar use.

(*c*) No fires are set out of doors from March to December without a permit from him.

(*d*) The power to arrest without a warrant where persons are caught setting fires.

(*e*) Appoints his deputies.

(*f*) Has charge of local forest fire apparatus.

(*g*) Posts forest fire notices.
(*h*) Has responsibility of controlling brush and slash disposal.
(*i*) Gives assistance to assessors when called upon to secure data for forest taxation.

The State is divided into four parts and each of these divisions is looked after by a so-called district forest warden. This man is appointed by the State Fire Warden and is supplied with a runabout auto. It is the duty of the district forest wardens to supervise the work of fire protection within their respective districts. They have charge of the observation stations within their districts, receive reports from the observers each week, and are at all times subject to the call of each observer to attend any disastrous fire. They shall visit all towns within their districts, instructing the town forest wardens and deputy forest wardens relative to their duties, making such recommendations as in their judgment will improve the service. They shall inspect all forest fire-fighting apparatus, seeing that the same is in perfect condition and in readiness for an immediate response to an alarm of fire. They shall visit the selectmen of the different towns, advising them as to the necessity of properly providing their towns with forest fire-fighting apparatus. They shall report the number of each locomotive operating in their district not properly equipped with spark arrester, as required by law, and whose ash-pan and grate are not sufficiently protected from setting fires. They shall submit to this office a weekly report showing the work accomplished by them each day, and shall report to this office any inefficiency or neglect of any observation man, forest warden or deputy.

The surface of the State of Massachusetts is of a rolling nature and particularly well adapted for fire look-out stations, utilizing its higher hills and mountains. During the past three years, 26 of these stations have been in operation throughout the State. At first improvised towers were used, but now substantial ones of steel construction ranging in size from 40 feet high, which is the standard, to 75 feet.

The position of observer on the lookout station is the most important position under our present forest-fire system. The future preservation of the forests of the State of Massachusetts depends largely on the men in charge of these stations. If they are alive to the situation, and appreciate the importance of the position they hold, disastrous fires within this State will be eliminated.

Each observer has under his supervision over 400,000 acres of land, a large percentage of which is valuable forest land. He is equipped with a field glass and the best map that can be obtained, and has the names and telephone numbers of every town forest warden and deputy forest warden within his territory. There has also been placed in each station a time-clock, to be punched every half hour, showing the exact time the observer is at his station, and the daily slips are to be forwarded, with the weekly report, to the State Fire Warden at the end of each week. The clock system affords a protection not only to the State but to the man in charge of the observation station as well. Each observation man is directly under the supervision of the district forest warden, and shall forward him a copy of his weekly report. He must become thoroughly familiar with the territory under his supervision, studying the map and country carefully, becoming familiar with the names of the different mountains, hills, streams, ponds, roads, trails, railroads, and trolley lines. He should know the local names which prevail in the region, the settlements where help may be collected quickly in case of fire; and the telephone connections in all directions from the station. All such information will assist in getting help to a fire as soon as smoke arises.

The weekly report has printed instructions on the back. This report is to be filled out each day, regardless of whether any fires are observed or not. If there are no fires, one line should be used each day, showing weather conditions, wind, etc. All fires observed must be reported. The observer must be very particular about the location of a fire, time observed, whom notified, time of notification and time extinguished. He should keep his telephone in work-

ing order, calling up the central office each morning and after storms, to determine whether or not the line is in working order. If it fails to work, he should go over the line and try to find breaks and get it in working condition as promptly as possible. In case of inattention or failure of any of the town forest wardens or their deputies he should notify the district forest warden and the State Forester's office.

(4) **Forestry Conventions.**—In order to enable the various officials to keep in close touch with the forest wardens throughout the State, and also to enable neighboring groups of wardens to discuss methods, equipment, etc., the State Forester is allowed to spend not to exceed $2,000 for conventions during a year. While forest fires, their control and management form a very important part of the program, such subjects as reforestation, thinning and general forestry improvement practices are discussed.

(5) **State Aid for Forest Fire Equipment.**—Massachusetts expects its towns with a valuation of over one million seven hundred and fifty thousand dollars to be able to support its own forest fire equipment, but all towns having a valuation below this amount, the State agrees to reimburse for fifty percent. of an expenditure not to exceed $500. This has encouraged our poorer towns to greater protection. The forest fire lookout stations have been built usually on the cooperative plan, the towns covered paying one-half and the State the remainder.

(6) **Utilization.**—No more important part of forestry needs attention than does that of finding the best use for all products. Massachusetts was the first State to publish a bulletin on Forest Utilization. This was done in cooperation with the United States Forest Service. We are at present continuing these studies and have some very promising experiments being carried on.

(7) **Brush and Slash.**—One of the great causes for the larger forest fires and hence those of greatest damage has come from fire getting into old slashings or brush left from operating lots. A law was enacted last year making it compulsory for everyone operating a tract of forest land to leave a forty-foot strip free of slash or brush as a natural

fire prevention line along the highways, railroad locations and all abutters' lands where there is danger from fire; it takes effect beginning January 1, 1915.

(8) **Railroad Fires and Railroads.**—A State law compels all railroad engines to carry spark arresters and by an order from the Public Service Commission all engines running in Massachusetts are subject to examination by agents deputized for this work. The commission has a special man in charge of this inspection and the State Fire Warden also permanently assigns one of his deputies to overcoming railroad fires. They are experts on the inspection of spark arresters, ash pans, grates, etc.

The signal for all forest fires is a whistle of one long and three short blasts and all engineers are required by law to comply with it.

By a Massachusetts law all expenses a town or city may have incurred in extinguishing railroad fires are reimbursed by the railroads responsible. This is in addition to the property damages themselves.

Since these enactments, far better cooperation has resulted and railroad fires are rapidly diminishing.

At our Forest Warden Conventions the railroads are always represented.

(9) **Forest Taxation.**—Few subjects have received more agitation in Massachusetts than this one. An amendment of the State constitution—a process of several years, was found necessary, followed by confirmation on the part of the people. Last year, however, the recommendations of a special forest taxation commission were adopted. At present, therefore, we have a modern system of taxing forest lands. Briefly, there is an annual tax upon the land at cut-over valuation and then a so-called products tax is assessed when the products are harvested. This law safeguards anyone who desires to invest in forestry from being imposed upon, and as well expects from the owner recognized methods of culture.

(10) **Reforestation Assistance to Owners.**—A Massachusetts law is in force whereby anyone having a tract of forest land adapted to reforestation, may, by turning the title

over to the State Forester temporarily, have it reforested for him at cost. The tract is then supervised by the State Forester until the owner cares to redeem the same. The period for redemption is ten years, and thereafter it becomes the property of the State. This law has been very popular and has enabled the State Forester to start forestry work in many sections where individuals would not have the time or feel experienced enough to undertake the work. As the law contemplated scattering the work over the State as demonstrations and object lessons, the tracts thus planted range from ten to eighty acres. The State in some instances has bought tracts for such use, but in this case the law restricts the acreage in any one year to eighty acres in one place. When land has been thus handled for the individual, and has been redeemed, the owner is required to thereafter handle the plantation according to modern forestry methods.

In doing this work the State Forester, of course, is anxious to demonstrate and satisfy the owner that the work is economically and properly done. This encourages others to do similar work who do not care to turn the title over to the State. Either method is getting results and that is the goal in view.

(11) **Causes and Numbers of Forest Fires.**—Each season we have secured more definite data as to causes of fires and through a better checking-up system practically all fires are now reported to the State Fire Warden. Blank forms are filled out by the forest warden after each fire, and mailed to the State Forester's Office. With the causes of forest fires well understood, it is less difficult to study out ways and means of obviating them.

(12) **State Forests.**—Our recent legislature enacted a law empowering the Governor to appoint two State forest commissions who, with the State Forester, are to purchase lands for State forests. The sum of $90,000 was appropriated for this purpose. The commission is restricted in the purchase price of the proposed forests. They are not allowed to pay over five dollars an acre on the average. The policy of the State is to establish these proposed forests on lands now unproductive and likely to remain so, did the State not

step in and reclaim them for forestry. Already the commission has gone over the State quite thoroughly and many prospective tracts are in view. These tracts will give the State Forester an opportunity to demonstrate forestry on a more pretentious scale.

(13) **State Forest Nurseries.**—The State of Massachusetts grows its own small trees. A nursery of seven acres is established on the farm of the Massachusetts Agricultural College at Amherst, and another of four acres is located at Barnstable on the Cape. Last year our inventory showed 7,000,000 trees and our seed beds are increased in numbers this season.

A nursery has been started at the Massachusetts State Farm at Bridgewater and this will be enlarged upon for transplant stock next season. With the advent of State-owned forests we will need a large output of young stock.

(14) **Lectures and Exhibitions.**—The State Forester and his assistants are called upon for talks and lectures by many organizations, colleges, schools, boards of trade, etc., and it has been through this medium that many people have been interested in forestry. The State Forester alone gave fifty-four talks and lectures one season. This season the department has a new feature in demonstrating its work by moving pictures. Numerous exhibits are made of the State work each year at various fairs, food shows, sportsmen shows, etc. A State Forester's Exhibit is being prepared at the present time for the Panama-Pacific Exposition at San Francisco next year.

(15) Other regulations worthy of mention are:

(*a*) Power of the Governor to issue a proclamation closing the open season for hunting in dry times. This action was taken in the State this fall for the first time in many years.

(*b*) Boy scouts are voluntarily becoming our best forest fire fighters. Cooperative encouragement here brings remarkable results.

(*c*) Fish and game deputies have the same authorities in many respects as forest wardens. They are required to report all fires to the forest wardens.

(*d*) The rural mail carriers who penetrate practically every forest section of the State are required to report all forest fires to the forest wardens in their territory. Three hundred carriers throughout the State, travelling a total mileage of 6,000 miles each day, are of great assistance in getting help to extinguish fires in their incipiency.

In conclusion, I trust I have at least given you a general idea of what the Massachusetts State Forestry Work is. Much more might be pointed out, as for example the great undertaking in the suppression of the gypsy and the brown-tail moths which Massachusetts is doing at great expense, but which has already been discussed by the writer before this association.

The most important point I wish to make is that the forestry work in Massachusetts has definitely progressed and now that enough laws and general regulations are at hand for encouragement in forestry, it is believed we shall see more rapid development along modern forestry lines.

Past Presidents.

Term began		Expired
1880	W. J. Beal, *of Michigan*	1882
1881	W. H. Brewer, *of Connecticut*	1884
1884	H. E. Alvord, *of New York*	1886
1886	E. L. Sturtevant, *of New York*	1887
1887	R. C. Kedzie, *of Michigan*	1889
1889	C. E. Bessey, *of Nebraska*	1891
1891	I. P. Roberts, *of New York*	1893
1893	W. Saunders, *of Ontario, Canada*	1895
1895	W. R. Lazenby, *of Ohio*	1897
1897	B. D. Halsted, *of New Jersey*	1899
1899	W. J. Beal, *of Michigan*	1901
1901	W. H. Jordan, *of New York*	1903
1903	William Frear, *of Pennsylvania*	1905
1905	H. P. Armsby, *of Pennsylvania*	1907
1907	T. F. Hunt, *of Pennsylvania*	1909
1909	S. M. Tracy, *of Mississippi*	1911
1911	Eugene Davenport, *of Illinois*	1913
1913	H. J. Waters, *of Kansas*	

Past Secretaries.

1880	E. L. Sturtevant, *of Massachusetts*	1882
1882	G. C. Caldwell, *of New York*	1883
1883	F. A. Gulley, *of Mississippi*	1885
1885	B. D. Halsted, *of Iowa*	1886
1886	W. R. Lazenby, *of Ohio*	1891
1891	L. O. Howard, *of District of Columbia*	1893
1893	W. Frear, *of Pennsylvania*	1895
1895	C. S. Plumb, *of Indiana*	1899
1899	T. F. Hunt, *of Ohio*	1900
1900	F. M. Webster, *of Illinois*	1905
1905	F. W. Rane, *of Massachusetts*	1910
1910	E. W. Allen, *of District of Columbia*	1914
1914	L. A. Clinton, *of District of Columbia*	

MEMBERSHIP OF THE SOCIETY.

Honorary Member.

1899. HON. JAMES WILSON, LL. D., *Traer, Iowa.*

Regular Members.

(Arranged Alphabetically.)

The prefixed date is the year of election.

1907. EDWIN WEST ALLEN, B. S. (Mass. Agri. Coll. and Boston Univ., '85), Ph. D. (Göttingen, '90); *U. S. Dept. Agri., Washington, D. C.;* Asst. Chem. Mass. Expt. Sta., '85–'88; Asst. Office Expt. Stas., '90–'93; Asst. Dir., do., '93—; Ed. Expt. Sta. Record, '95—.

1913. HARRY ORSON ALLISON, B. S. (Univ. Ill., '06), M. S. (do., '06); *Columbia, Mo.;* Instr. and Asst. in Anim. Husb., Univ. Ill., and Expt. Sta., '06–'10; Asst. Prof. Anim. Husb., Univ. Mo., '10–'12; Assoc. Prof., do., and Anim. Husb. Mo. Expt. Sta., '12—.

1913. JOHN W. AMES, B. S. (Case School Appl. Sci., '98), M. S. (do. '06); *Wooster, Ohio;* Chem., Ohio Expt. Sta., '99—.

1889. HENRY PRENTISS ARMSBY, B. S. (Worcester Poly. Inst., '71), Ph. B. (Sheffield Sci. School, '74), Ph. D. (Yale Univ., '79), LL. D. (Univ. Wis., '04); *State College, Pa.;* Chem. Conn. Expt. Sta., '77–'81; Vice Prin. Storrs Agr. School, '81–83; Prof. Agr. Chem., Univ. Wis., '83–'87; Dir. Pa. Expt. Sta., '87–'07; Dean School of Agr., Penn. State College, '95–02; Dir. Inst. Animal Nutrition, '07—.

1886. JOSEPH CHARLES ARTHUR, B. S. (Iowa State Coll., '72), M. S. (do., '77), D. Sc. (Cornell Univ., '86); *Lafayette, Ind.;* Instr. Biol., Iowa State Coll., '76–'78; Instr. Bot., Univ. Wis., '79–'81; do., Univ. Minn., '82; Bot. N. Y. Expt. Sta., '84–87; Prof. Bot., Purdue Univ., '87–'88; Prof. Veg. Phys. and Path., do., and Bot., Ind. Expt. Sta., '88—.

1906. LIBERTY HYDE BAILEY, B. S. (Mich. Agr. Coll., '82), M. S. (do., '85), LL. D. (Univ. Wis., '07); *Ithaca, N. Y.;* Prof. Hort. and Landscape Gardening, Mich. Agr. Coll., '84–'88; Prof. Hort., Cornell Univ., '88–'03; Dir. Coll. Agr. and Expt. Sta., Cornell Univ., '03–'13; Editor and writer, '13—.

1914. ELMER DARWIN BALL, B. S. (Iowa St. Coll., '95); M. S. (do., '98); Ph. D. (Ohio State Univ., '07); *Logan, Utah;* Asst. in Zool. and Ento., Colo. Agr. Coll., '97–'02; Prof. Zool. and Ento., Utah Agr. Coll., '02–'07; Dean School Agr. and Dir. Expt. Sta., Utah Agr. Coll., '07—.

1909. Walter Henry Beal, A. B. and M. E. (Va. Poly. Inst., '86); *Washington, D. C.;* Asst. Chem. Mass. Expt. Sta., '87–'91; Asst. Office of Expt. Stas., U. S. D. A., '91–'02; Chief of Editorial Division, do., '02—.

1879. William James Beal, A. B. (Univ. Mich., '59), A. M. (do., '63), Sc. B. (Harvard Univ., '65), Sc. M. (Univ. Chicago, '75), Ph. D. (Univ. Mich., '80), D. Sc. (Mich. Agr. Coll., '05); *Amherst, Mass.;* Prof. Bot., Mich. Agr. Coll., '70–'72; Prof. Bot. and Hort., '72–'81; Prof. Bot. and Forestry, '81–'03; Prof. Bot., '03–'10; Prof. Emeritus, '10—.

1912. Augustine Wilberforce Blair, B. S. (Haverford, '92), A. M. (do., '96); *New Brunswick, N. J.;* Prof. Chem., Guilford Coll., '96–'97; Asst. Chem., N. C. Expt. Sta., '97–'98; State Chem., N. C., '98–'99; Asst. Chem., Fla. Expt. Sta. and Univ. Fla., '99–'06; Chem., Fla. Expt. Sta., '06–'12; Assoc. Soil Chem., N. J. Expt. Sta., '12—.

1913. Maurice Adin Blake, B. S. (Mass. Agr. Coll., '04); *New Brunswick, N. J.;* Asst. Hort., R. I. Agr. Coll. and Expt. Sta., '04–'05; Instr. Hort., Mass. Agr. Coll., '05–'06; Hort., N. J. Expt. Stas., '06—.

1893. Henry Luke Bolley, B. S. (Purdue Univ., '88), M. S. (do., '89); *Agricultural College, N. Dak.;* Instr. Biol. and Asst. Bot. to Expt. Sta., Purdue Univ., '90; Prof. Bot. and Plant Path., N. Dak. Agr. Coll. and Bot. and Plant Path. of Expt. Sta., do., '90—.

1909. William Penn Brooks, B. Sc. (Mass. Agr. Coll., '75), Ph. D. (Halle, '97); *Amherst, Mass.;* Prof. Agr. Imp. Coll. Agr., Sapporo, Japan, '77–'88; Prof. Bot., do., '81–'88; Pres., do., *ad interim* '80–'83 and '86–'87; Prof. Agr. and Agr., Mass. Agr. Coll. and Expt. Sta., '89–'09; acting Pres. and Dir., do., '05, '06; Dir. Expt. Sta., '06—.

1905. Burt C. Buffum, B. S. (Col. Agr. Coll., '90), M. S. (do., '93); *Worland, Wyo.;* Asst. Met. and Irr. Eng., Col. Agr. Coll., '90–'91; Prof. Hort. and Met., Univ. Wyo. and Bot. Wyo. Expt. Sta., '91–'92; Prof. Agr. and Hort., do., '91–'00; Vice Dir. do Expt. Sta., '96–'00; Prof. Agr., Col. Agr. Coll., '00–'02; Dir. Wyo. Expt. Sta., and Prof. Agr. and Hort., Univ. Wyo., '02–'07; Plant Breeder and Mgr. Wyo. Seed Breeding Co., '07—.

1901. Edgar Allen Burnett, B. S. (Mich. Agr. Coll., '87); *Lincoln, Nebr.;* Asst. Mich. Agr. Coll., '89–'93; Prof. Anim. Husb., S. Dak. Agr. Coll., '96–'99; Prof. Anim. Husb., Univ. Nebr., '99–'07; Dir. Nebr. Expt. Sta., '01—; Dean Coll. Agr., '09—.

1908. Kenyon L. Butterfield, B. S. (Mich. Agr. Coll., '91), A. M. (Univ. Mich., '02); *Amherst, Mass.;* Supt. Mich. Farmers'

Institutes, '95–'99; Instr. Univ. Mich., '02; Pres. Rhode Island Coll., '03–'06; Pres. Mass. Agr. Coll. and Head Div. Rural Sociol., '06—.

1909. FRANK KENNETH CAMERON, A. B. (Johns Hopkins, '91), Ph. D. (do., '94); *Washington, D. C.;* Fellow Cornell, '94–'95; Assoc. Prof., Catholic Univ., '95–'97; Asst. Physical Chem., Cornell, '97–'98; Expert, U. S. D. A., '98–'99; Soil Chemist, do., '99—.

1914. IRA DETRICK CARDIFF; B. S. (Knox Coll., '99); Grad. Stud. Univ. of Chicago, '02, '03, '04; Ph. D. (Columbia Univ., '06); *Pullman, Wash.,* Asst. in Bot., Columbia Univ., '04–'06; Asst. Prof. of Bot., Univ. of Utah, '06–'07; Prof. of Bot., do., '07–'08; do. Washburn Coll., '08–'12; do. Univ. of Kans., '12; Prof. of Plant Physiol. and Bact., State Coll. of Wash., 1913; Dir., State Expt. Sta., State Coll. of Wash., '13—.

1908. MARK ALFRED CARLETON, B. S. (Kans. Agr. Coll., '87), M. S. (do., '93); *Washington, D. C.;* Asst. Bot., Kans. Expt. Sta., '92–'93; Cerealist, Bur. Plant Indus., U. S. D. A., '94–'12; Gen. Mgr., Penn. Chestnut Tree Blight Com., '12–'13; Cerealist, Bur. Plant Indus., U. S. D. A., '13—.

1905. LOUIS GEORGE CARPENTER, B. S. (Mich. Agr. Coll. '79), M. S. (do., '84), LL. D. (do., '07); *707 First Nat. Bank Bldg., Denver, Col.;* Asst. Prof., Mich. Agr. Coll., '85–'88; Irr. Eng., Col. Agr. Coll. and Expt. Sta., '88–'10; Dir. Expt. Sta., do., '99–'10; State Eng., '03–'05; Consulting Irrigation Engineer, '10—.

1901. LOUIS ADELBERT CLINTON, B. S. (Mich. Agr. Coll., '89), M. S. (do., '97); *U. S. Dept. Agr., Washington, D. C.;* Asst. to Dir. Mich. Expt. Sta., '89–'93; Asst. Prof. Agr, Clemson Coll., '93–'95; Asst. Agr., Cornell Expt. Sta., '95–'02; Dir. Storrs Expt. Sta. and Prof. Agr., Conn. Agr. Coll., '02–'12; Agriculturist, Bur. Plant Indus., '12—.

1910. JOHN WALDO CONNAWAY, D. V. S. (Chicago Vet. Coll., '90), M. D. (Univ. Mo., '91); *Columbia, Mo.;* Prof. Physiology, Univ. Mo., '91–'97; Vet. Expt. Sta., do., '97–'00; Prof. Compar. Med. and Vet. to Expt. Sta., Univ. Mo., '00—.

1910. LEE CLEVELAND CORBETT, B. S. (Cornell Univ., '90), M. S. (do., '96); *Washington, D. C.;* Asst. Hort., Cornell Univ., '91–'93; Prof. Hort. and Forestry, S. Dak. Coll., '93–'95; do., Univ., W. Va. and Expt. Sta., '95–'01; Hort., U. S. Dept. Agr., '01–'13; Asst. Chief, Bur. Plant Indus., do., '13–'14; Hort. do., '14—.

1914. ARTHUR BURTON CORDLEY, B. S. (Mich. Agr. Coll., '88), M. S. (do., '01); *Corvallis, Ore.;* grad. student, Cornell Univ., '00–'07; Asst. in Ento., Mich. Agr. Coll., '88–'90;

Asst. Ento. Vt. Expt. Sta., '90–'91; Asst. Ento., U. S. D. A., '91–'93; Prof. Zool. and Ento. Expt. Sta., Ore. Agr. Coll., '95–'12; Dean, School of Agr., do., '07—; Dir. of Expt. Sta., do., 1914—.

1902. CHARLES FRANCIS CURTISS, B. S. A. (Iowa State Coll., '87), M. S. A. (do., '93), D. Sc. (Mich. Agr. Coll., '07); *Ames, Iowa;* Asst. Dir. Iowa Expt. Sta., '91–'97; Prof. Agr. and Acting Dir., Iowa Expt. Sta., '97–'00; Prof. Agr. and Dir., do., 00–'02; Dean and Dir., '02—.

1911. WILLIAM HADDOCK DALRYMPLE, M. R. C. V. S. England, '86; *Baton Rouge, La.;* Prof. Vet. Sci., La. State Univ., '89—; Vet., La. Expt. Sta., '89—.

1906. EUGENE DAVENPORT, B. S. (Mich. Agr. Coll., '78), M. S. (do., '81), M. Agr. (do., '95), LL. D. (do., '07); *Urbana, Ill.;* Prof. Agr., Mich. Agr. Coll., '89–'90; Dir. Coll. of Agr., Piracicaba, Brazil, '91–'92; Dean Coll. of Agr., Univ. Ill., '95—; Dir. Agr. Expt. Sta., '96—.

1913. ROBERT JOHN H. DELOACH, A. B. (Univ. Ga., '98), A. M. (do., '06); *Experiment, Ga.;* Bot., Ga. Expt. Sta., '06–'08; Prof. Cotton Indus., Univ. Ga., '08–'13; Dir., Ga. Expt. Sta., '13—.

1911. WILLIAM RUFUS DODSON, B. S. (Univ. Mo., '90), A. B. (Harvard Univ., '94); *Baton Rouge, La.;* Asst. Biol., Univ. Mo., '90–'93; Prof. Bot., La. Univ., '94–'02; Asst. Dir., La. Expt. Stas., '02–'05; Dir., do., '05—; Dean, Coll. Agr., La. Univ., '09—.

1897. BENJAMIN MINGE DUGGAR, B. S. (Miss. Agr. Coll., '91), M. S. (Ala. Poly. Inst., '92), A. B. (Harvard Univ., '94), A. M. (do., '95), Ph. D. (Cornell Univ., 98); *Missouri Botanical Garden, St. Louis, Mo.;* Asst. Ill. State Lab. Nat. Hist., '95–'96; Instr. Bot., Cornell Univ. and Asst. Cryptg. Bot., Expt. Sta., '96–'99; Asst. Prof. Bot., Cornell, '00–'01; Physiologist, U. S. Dept. Agr., '01–'02; Prof. Bot., Univ. Mo., '02–'07; Plant Physiologist, Coll. Agr. and Expt. Sta., Cornell Univ., '07–'12; Research Prof. Plant Physiol., Wash. Univ., '12—.

1910. JOHN FREDERICK DUGGAR, B. S. (Miss. Agr. Coll., '87), M. S. (do., '88); *Auburn, Ala.;* Asst. in Agr., Tex. Agr. Coll., '87–'89; Asst. Dir., S. C. Expt. Sta., '90–'92; Agr. Editor Office Expt. Stas., U. S. D. A., '93–'95; Prof. Agr., Ala. Poly. Inst., '96—; Dir. Ala. Expt. Sta., 03—.

1913. CLARENCE HENRY ECKLES, B. S. A. (Iowa State Coll., '95), M. S. (do., '97); *Columbia, Mo.;* Instr. and Asst. in Dairying, Iowa Coll. and Expt. Sta., '96–'01; Asst. Prof. Dairy Husb., Univ. Mo., and Dairyman Mo. Expt. Sta., '01–'06; Prof. and Dairyman, do., '06—.

1899. DAVID GRANDISON FAIRCHILD, B. S. (Kans. State Coll., '88), M. S. (do., '93); *Washington, D. C.;* Naples Zool. Sta., '93; Breslau and Berlin, '94; Bonn, '95; Buitenzorg Botanic Gardens, '96; Asst. Path. U. S. Dept. Agr., '89–'92; Special Agt. in charge Seed and Plant Introduction, '97–'98; Agr. Explorer, '98–'03; in charge Foreign Seed and Plant Introduction, U. S. Dept. Agr., '03—.

1880. WILLIAM GIBSON FARLOW, A. B. (Harvard Univ., '66), M. D. (do., '70), LL. D. (do., '96; Univ. Glasgow, '01; Univ. Wis., '04); *24 Quincy St., Cambridge, Mass.;* Asst. Prof. Bot., Harvard Univ., '74–'79; Prof. Cryptg. Bot., do., '79—.

1909. EDWARD HOLYOKE FARRINGTON, B. S. (Univ. Me., '81), M. S. (Yale, '82); *Madison, Wis.;* Chem., Conn. State Expt. Sta., '83–'89; do., Ill. Expt. Sta., '90–'94; Assoc. in Dairy Husb., Wis. Univ. and Expt. Sta., '94–'00; Prof. Dairy Husb., do., '00—.

1890. BERNHARD EDWARD FERNOW (Münden Forest Acad. grad., '73) LL. D. (Univ. Wis., '97; Queen's '03); *Toronto, Can.;* Chief, Div. Forestry, U. S. Dept. Agr., '86–'98; Dir. N. Y. State Coll. of Forestry, '98–'03; Lecturer Yale Forestry School, '04; Prof. of Forestry, Univ. of Toronto, '07—.

1911. MARTIN LUTHER FISHER, B. S. (Purdue Univ., '03), M. S. (Univ. Wis., '11); *Lafayette, Ind.;* Asst. in Agr., Purdue Univ., '03–'04; Instr. Agr., do., '04–'06; Asst. Prof. Agron., do., '06–'08; Assoc. Prof. Agron., do., '08–'10; Prof. Crop Prod., do., '10—; Asst. Agr., Indiana Expt. Sta., '03–'10; Assoc. in Crops, do., '10—.

1910. ERNEST BROWNING FORBES, B. Sc. (Univ. Ill., '97), B. S. Agr. (do., '02), Ph. D. (Univ. Mo., .08); *Wooster, Ohio;* Zool. Asst., Ill. Biol. Sta., '94–'96; Asst. to State Ento. of Minn., '97–'98; Acting State Ento. Minn., '01; Asst. in Anim. Husb., Ill. Expt. Sta., '01–'02; Instr. Anim. Husb., Univ. Ill., '02–'03; Asst. Prof. Anim. Husb., Univ. Mo., '03–'07; Chief in Nutr., Ohio Expt. Sta., '07—.

1908. STEPHEN ALFRED FORBES, Ph. D. (Ind. Univ., '84), LL. D. (Univ. Ill., '05), *Urbana, Ill.;* Prof. Zool., Univ. Ill., '84–'09; State Ento. Ill., '82—; Dir. Ill. State Lab. of Nat. Hist., '77—; Dean Coll. of Sci., Univ. of Ill., '88—.

1911. GEORGE STRONACH FRAPS, B. S. (N. C. Agr. Coll., '96), Ph. D. (Johns Hopkins Univ., '99); *College Station, Tex.;* Asst. Prof. Chem., N. C. Agr. Coll., and Asst. Chem. in Expt. Sta., '99–'03; Asst. Chem., Tex. Expt. Sta., '03–'04; Assoc. Chem., do., '04–'05, Chem., do., '05—; Assoc. Prof. Chem., Tex. Agr. Coll., '03–'05; Acting Prof., do., '05–06; Assoc. Prof. Agr. Chem., do., '06—; State Chem., '06—.

1888. WILLIAM FREAR, A. B. (Bucknell Univ., '81), Ph. D. (Ill. Wesleyan Univ., '83); *State College, Pa.;* Asst. Sci., Bucknell Univ., '81–'83; Asst. Chem. U. S. Dept. Agr., '83–'85; Prof. Agr. Chem., Pa. State Coll., '85—; Vice Dir. and Chem., Pa. Expt. Sta., '87—.

1913. JONS AUGUST FRIES, B. S. (Pa. State Coll., '99), M. S. (do., '06); *State College, Pa.;* Asst. Chem., Pa. Expt. Sta., '89–'98; Expert Asst. Anim. Nutr., do., '98–'08; Asst. Dir. Inst. Anim. Nutr., '08—.

1908. BEVERLY THOMAS GALLAWAY, B. S. (Univ. Mo., '84), LL. D. (do., '02); *Ithaca, N. Y.;* Asst. Hort., Univ. Mo., '84–'87; Asst. Path., U. S. Dept. Agr., '87–'88; Path. and Chief, Div. Veg. Path. and Physiol., do., '88–'01; Chief Bur. Plant Indus., do., '01–'13; Asst. Sec. of Agr., '13–'14; Dean N. Y. State Coll. of Agr. at Cornell Univ.; Dir. Cornell Univ. Agr. Expt. Sta., '14—.

1894. HARRISON GARMAN, *Lexington, Ky.;* Asst. State Lab. Nat. Hist., Ill., '83–'89; Asst. Prof. Zool., Univ. Ill., '85–'89; Ento. and Bot., Ky. Expt. Sta., '89—; State Ento., Ky. '97—.

1894. CHARLES CHRISTIAN GEORGESON, B. S. (Mich. Agr. Coll., '78), M. S. (do., '82); *Sitka, Alaska;* Asst. Ed. of *Rural New Yorker,* '78–'80; Prof. Agr. and Hort., Tex. Agr. Coll., '80–'83; Prof. Agr. Coll. of Agr., Imperial Univ., Tokyo, Japan, '86–'89; Prof. Agr., Kans. State Agr. Coll., '90–'97; Special Agt. U. S. Dept. Agr., Dairy Industry, Denmark, '93; Asst. Agrostologist, U. S. Dept. Agr., '97–'98; Special Agt. in charge Alaska Expt. Sta., do., '98—.

1893. CLARENCE PRESTON GILLETTE, B. S. (Mich. Agr. Coll., '84), M. S. (do., '88); *Fort Collins, Col.;* Asst. Zool., Mich. Agr. Coll., '87–'88; Ento. Iowa Expt. Sta., '88–'91; Prof. Zool. and Ento., Col. Agr. Coll. and Ento. Expt. Sta., do., '91—; Dir. Expt. Sta., do., '10—.

1911. ARTHUR GOSS, B. S. (Purdue Univ., '88), M. S. (do., '95); *Lafayette, Ind.;* Asst. Chem., Ind. Expt. Sta., '88–'92; Asst., Ind. Weather Serv., '89–'92; Prof. Chem., N. Mex. Agr. Coll., and Chem. in Expt. Sta., '92–'03; Vice-Dir., N. Mex. Expt. Sta., '95–'00; Dir., Ind. Expt. Sta., '03—.

1909. HARRY SANDS GRINDLEY, B. S. (Univ. Ill., '88), Sc. D. (Harvard, '94); *Urbana, Ill.;* Asst. Chem., Univ. Ill., '88–'92; Asst. Chem., Harvard, '92–'93; Fellow Harvard, '93–'94; Instr. Chem., Univ. Ill., '94–'95; Asst. Prof. Chem., do., '95–'99; Assoc. Prof. Chem., do., '99–'04; Prof. and Dir. Chem. Lab., do., '04–'07; Prof. An. Chem., do., and Chief An. Chem., Expt. Sta., '07—.

1909. THEOPHILUS L. HAECKER, *University Farm, St. Paul, Minn.;* in charge Dairy Husb., Minn. Univ. and Expt. Sta., '92–'07; Prof. Dairy Husb. and Anim. Nutrition, do., '07–'09; Prof. Dairying, Anim. Husb. and Animal Nutrition, do., '10—.

1880. BYRON DAVID HALSTED, B. S. (Mich. Agr. Coll., '71), M. S. (do., '74), Sc. D. (Harvard Univ., '78); *New Brunswick, N. J.;* Ed. *American Agriculturist*, '79–'85; Prof. Bot., Iowa State Coll., '85–'89; Prof. Bot. and Hort., Rutgers Coll., '89–'10; Bot., N. J. Expt. Sta., '89—.

1902. NIELS EBBENSEN HANSEN, B. S. (Iowa State Coll., '87), M. S. (do., '95); *Brookings, S. Dak.;* Asst. Prof. Hort., Iowa State Coll., '91–'95; Prof. Hort. and Forestry, S. Dak. Agr. Coll., and Hort., Expt. Sta., '95—.

1910. JOSEPH NELSON HARPER, B. S. (Miss. Agr. Coll., '95), M. A. (Ky. Agr. Coll., '06); *Clemson College, S. C.;* Dairy Husb., Miss. Expt. Sta., '95; Dairy Husb., Ky. Expt. Sta., '96–'98; Agriculturist, do., '98–'05; Dir. and Agron., S. C. Expt. Sta., '06—.

1911. EDWIN BRET HART, B. S. (Univ. Mich., '97); *Madison, Wis.;* Asst. Chem., N. Y. Expt. Sta., '97–'00; Assoc. Chem., do., '06; Prof. Agr. Chem., Univ. Wis., and Chem., Wis. Expt. Sta., '06—.

1910. BURT LAWS HARTWELL, B. S. (Mass. Agr. Coll. and Boston Univ., '89), M. S. (Mass. Agr. Coll., '00), Ph. D. (Univ. Pa., '03); *Kingston, R. I.;* Asst. Chem., Mass. Expt. Sta., '89–'91; Asst. Chem., R. I. Expt. Sta., '91–03; Assoc. Chem., do., '03–'07; Chem., do., '07—; Prof. Agr. Chem., R. I. State Coll., '08—; Dir., R. I. Expt. Sta., '13—.

1905. WILLET MARTIN HAYS, B. Agr. (Iowa State Coll., '85), M. Agr. (do., '86); *Kennett Sq., Pa.;* Asst. Iowa Agr. Coll., '86; Assoc. Ed., *Prairie Farmer*, '87; Asst. in Agr., Iowa Agr. Coll., '88–'89; Prof. Agr. and Agriculturist, Minn. Agr. Coll. and Expt. Sta., '90–'91; Prof. Agr. and Agriculturist, N. Dak. Agr. Coll. and Expt. Sta., '92–'93; Prof. Agr. and Agriculturist, Minn. Agr. Coll. and Expt. Sta., '93–'04; Asst. Sec. of Agr., U. S. Dept. Agr., '04–'13; Farmer, '15—.

1911. HARRY HAYWARD, B. S. (Cornell Univ., '94), M. S. (do., '01); *Newark, Del.;* Asst. Prof. Dairy Husb., Pa. State Coll., '97–'02; Assoc. Prof. An. and Dairy Husb., N. H. Agr. Coll., '02–'03; Asst. Chief Dairy Div., U. S. Dept. Agr., '03; Dir. Agr. Dept., Mount Hermon School, '03–'06; Dean Agr. Dept., Del. Coll., and Dir. Del. Expt. Sta., '06—.

1909. WILLIAM PARKER HEADDEN, A. B. (Dickinson, '72), A. M. (do., '75), Ph. D. (Univ. Giessen, '74); *Fort Collins, Col.,* Asst., Univ. Pa., '74–'76; Prof. Chem., Md. Agr. Coll.,

'80–'84; do., Univ. Denver, '84–'89; do., S. Dak. School of Mines, '89–'91; Dean, do., '92–93; Prof. Chem. and Geol., Col. Agr. Coll., and Chem., Expt. Sta., '93—.

1909. ULYSSES PRENTISS HEDRICK, B. S. (Mich. Agr. Coll., '93), M. S. (do., '95); *Geneva, N. Y.;* Asst. Hort., Mich. Agr. Coll., '93–'95; Prof. Bot. and Hort., Ore. Agr. Coll., and Hort., Expt. Sta., '95–'97; Prof. Bot. and Hort., and Hort., Expt. Sta., Utah, '97–'99; Prof. Hort., Mich. Agr. Coll., '99–'05; Hort., N. Y. Expt. Sta., '05—.

1880. EUGENE WALDEMAR HILGARD, Ph. D. (Heidelberg, '53), LL. D. (Columbia Univ., '87); *Berkeley, Cal.;* State Geol., Miss., '58–'72; Prof. Chem., Univ. Miss., '66–'73; Prof. Geol. and Nat. Hist., Univ. Mich., '73–'75; Prof. Agr., Univ. Cal., and Agriculturist, Expt. Sta., '75–'06; Dir. Cal. Expt. Sta., '88–'06; Prof. Emeritus, '06—.

1905. JOSEPH LAWRENCE HILLS, B. S. (Mass. Agr. Coll. and Boston Univ., '81), D. Sc. (honorary, '03, Rutgers Coll.); *Burlington, Vt.;* Asst. Chem., Mass. Expt. Sta., '82–'83; Asst. Chem., N. J. Expt. Sta., '84–'85; Chem. Phos. Mining Co., Ltd., Beaufort, S. C., '85–88; Chem., Vt. Expt. Sta., '88–'98; Dir., do., '98—; Prof. Agr. Chem., Univ. Vt. '93—; Dean, Dept. Agr., do., '98—.

1911. CYRIL GEORGE HOPKINS, B. S. (S. Dak. Coll., '90), M. S. (Cornell Univ., '94), Ph. D. (do., '98); *Urbana, Ill.;* Asst. Chem., S. Dak. Agr. Coll. and Expt. Sta., '90–'92; do., Cornell Univ., '92–'93; Acting Prof. Pharm., S. Dak. Agr. Coll., '93–'94; Chem., Ill. Expt. Sta., '94—; Prof. Agron., Univ. Ill., '00—.

1889. LELAND OSSIAN HOWARD, B. S. (Cornell Univ., '77), M. S. (do., '86), Ph. D. (Georgetown Univ., '96); *Washington, D. C.;* Asst. Ento., U. S. Dept. Agr., '78–'94; Chief Ento., do., '94—; Perm. Sec., A. A. A. S., '98—.

1912. WALTER LAFAYETTE HOWARD, B. Agr., B. S. (Univ. Mo., '01), M. S. (do., '03), Ph. D. (Univ. Halle-Wittenberg, '06); *Columbia, Mo.;* Asst. in Hort., Univ. Mo., '01–'03; Instr., do., '03–'04; Asst. Prof., do., '05–'08; Sec., Mo. State Board Hort., '08–'12; Prof. Hort., Univ. Mo., '08—.

1903. THOMAS FORSYTH HUNT, B. S. (Univ. Ill., '84), M. S. (do., '92), D. Agr. (do., '04), D. Sc. (Mich. Agr. Coll., '07); *Berkeley, Cal.;* Asst. State Ento. of Ill., '85–'86; Asst. Agr., Univ. Ill., '86–'88; Asst. Agr., Ill. Expt. Sta., '88–'91; Prof. Agr., Pa. State Coll., '91–'92; Prof. Agr., Ohio State Univ., '92–'95; Dean Coll. Agr., Ohio State Univ., '95–'03; Prof. Agron., Cornell Univ., and Agron., Expt. Sta., '03–'06; Dean Coll. Agr., and Dir. Agr. Expt. Sta., Pa. State Coll., '06–'12; Dean Coll. Agr., Univ. Cal., and Dir. Expt. Sta., '12—.

1908. WILLIAM DANIEL HURD, B. S. (Mich. Agr. Coll., '99), M. Agr. (do., '08); *Amherst, Mass.*, Instr., Lansing High School, '99–'01; Prof. Hort., Briarcliff Agr. School, '01–'03; Prof. Agr., Univ. Me., '03–'05; Acting Dean, Coll. of Agr., do., '05–'06; Dean, '06–'09; Dir. of Extension Mass. Agr. Coll., '09—.

1898. HENRY CLAY IRISH, B. S. (S. Dak. Agr. Coll., '91), M. S. (Iowa State Coll., '98); *Missouri Botanical Garden, St. Louis, Mo.;* Hort. Asst., Mo. Bot. Gard., '95–'02; Supt., do '03—.

1908. MYER EDWARD JAFFA, Ph. B. (Univ. Cal., '77), M. S. (do., '96); *Berkeley, Cal.;* Asst. Chem., U. S. Census, '79–'80; Asst. Agr. Dept., Univ. Cal., '80–'81; Asst. Chem., Northern Transcontinental Surv., '81–'83; Asst. Chem., Univ. Cal., '83–'96; Asst. Prof. Agr., do. '96–'06; do., Nutr. '06–'08; Prof. Nutr., do., '08—.

1885. EDWARD HOPKINS JENKINS, A. B. (Yale Univ., '72), Ph. D. (do., '79); *New Haven, Conn.;* Chem., Conn. Expt. Sta., '76–'00; Vice Dir., do., '82–'00; Dir., do., '00—; Treas., do., '01—; Dir., Storrs Expt. Sta., '12—.

1894. WHITMAN HOWARD JORDAN, B. S. (Univ. Me., '75), M. S. (do., '79), D. Sc. (do., '96), LL. D. (Mich. Agr. Coll., '07); *Geneva, N. Y.;* Asst. Chem., Conn. Expt. Sta., '78–'79; Instr. Agr., Univ. Me., '79–'80; Prof. Agr. and Agr. Chem., Pa. State Coll., '81–'85; Dir., Me. Expt. Sta., '85–'96; Prof. Agr., Univ. Me., '94–'96; Dir., N. Y. Expt. Sta., '96—.

1912. JOHN CHESTER KENDALL, B. S. (N. H. Coll., '02); *Durham, N. H.;* Instr. in Dairy Husb., N. C. Agr. Coll., '02–'03; Asst. Prof. of Dairy Husb., do., '03–'06; State Dairy Comr., Kans., '06–'07; Prof. of Dairy Husb., Kans. Agr. Coll., '08–'10; Dir., N. H. Expt. Sta., '10—; Dir. of Ext. Work, N. H., '11—.

1909. BENJAMIN WESLEY KILGORE, B. S. (Miss. Agr. Coll., '88), M. S. (do., '90); *Raleigh, N. C.;* Asst. Chem., Miss. Agr. Coll., '88–'89; do., N. C. Expt. Sta., '89–'97; Prof. Chem., Miss. Agr. Coll. and Agr. Expt. Sta., '97–'99; State Chem., N. C., '99—; Dir., N. C. Expt. Sta., '01-'07; do., '13—.

1911. HENRY GRANGER KNIGHT, A. B. (Univ. Wash., Seattle, '02), A. M. (do., '04); *Laramie, Wyo.;* Asst. Chem., Univ. Wash., '00–'01; Instr., do., '01–'02; Asst. Chem., Univ. Chicago, '02–'03; Asst. Prof. Chem., Univ. Wash., '03–'04; Prof. Chem., Univ. Wyo., and State Chem., '04—; Dir., Wyo. Expt. Sta., '10—.

1889. EDWIN FREMONT LADD, B. Sc. (Univ. Me., '84); *Agricultural College, N. Dak.;* Asst. Chem., N. Y. State Expt. Sta., '84–'87; Chief Chem., do., '87–'90; Prof. Chem., N, Dak.

Agr. Coll. and Chem. Expt. Sta., '90—; Food Comr. and State Chem., N. Dak., '00—.

1883. WILLIAM RANE LAZENBY, B. Agr. (Cornell Univ., '74), M. Agr. (Iowa Agr. Coll., '87); *Columbus, Ohio;* Instr. Hort., Cornell Univ., '74–'77; Asst. Prof. Hort., do., '77–'81; Prof. Hort. and Bot., Ohio State Univ., '81–'82; Dir., Ohio Expt. Sta., '82–'87; Prof. Hort. and Forestry, Ohio State Univ., '82–'09; Prof. Forestry, do., '09—.

1899. JOSEPH BRIDGEO LINDSEY, B. Sc. (Mass. Agr. Coll., '83), Ph. D. (Univ. Göttingen, '92); *Amherst, Mass.;* Asst. Chem., Mass. State Expt. Sta., '83–'85; Commercial Chem., '85–'89; Assoc. Chem., Mass. State Expt. Sta., '92–'95; Head Dept. Foods and Feeding, Hatch Expt. Sta., '95–'07; Chem., Mass. Expt. Sta., '07—; Vice Dir., do., '09—; Head Dept. Chem., Mass. Agr. Coll. and Goessmann Prof. of Agr. Chem., '11—.

1911. FREDERICK BLOOMFIELD LINFIELD, B. S. A. (Ontario Agr. Coll., '91); *Bozeman, Mont.;* Asst. in Dairying, Ontario Agr. Coll., '92–'93; Prof. Anim. Indus. and Dairying, Utah Agr. Coll., '93–'02; Prof. Agr., Mont. Agr. Coll., '02—; Acting Dir., Mont. Expt. Sta., '03; Dir., do., '04—.

1912. CHARLES BERNARD LIPMAN, B. Sc. (Rutgers Coll., '04), M. Sc. (do., '09), M. S. (Univ. Wis., '09), Ph. D. (Univ. Cal., '10); *Berkeley, Cal.;* Instr. in Soil Bact., Univ. Cal., '09–'10; Asst. Prof. Soils, do., '10–'12; Assoc. Prof. of Soils, do., and Soil Chem. and Bact., Cal. Expt. Sta., '12—.

1909. JACOB G. LIPMAN, B. Sc. (Rutgers, '98), A. M. (Cornell, '00), Ph. D. (do., '03); *New Brunswick, N. J.;* Asst. Chem., N. J. Expt. Sta., '98–'99; Fellow Chem., Cornell, '01; Soil Chem. and Bact., N. J. Expt. Sta., '01—; Asst. Prof. Agr., Rutgers, '06–'07; Assoc., do., '07–'10; Prof. Soil Chem. and Bact., '10—; Dir., N. J. Expt. Stas., '11—.

1911. EDWARD READ LLOYD, B. S. (Ala. Poly. Inst., '87), M. S. (do., '88); *Agricultural College, Miss.;* Prof. Agr., Miss. Agr. Coll., '00–'05; Dir. Farmers' Insts., do., '06–'10; Vice Dir. and Anim. Husb., Miss. Expt. Sta., '10–'12; Dir., do., '12; Dir. Agr. Exten., '14—.

1911. CHARLES ALFRED LORY, B. Ped. (State Normal School, Greeley, Col., '98), B. S. (Univ. Col., '01), M. S. (do., '02), LL.D. (do., '09); *Fort Collins, Col.;* Asst. in Physics, Univ. Col., '99–'02; Prin. Cripple Creek High School, '02–'04; Acting Prof. Physics, Univ. Col., '04–'05; Prof. Physics and Elect. Engin., Col. Agr. Coll., '07–'09; Pres., do., '09—.

1899. ROBERT HILLS LOUGHRIDGE, B. S. (Univ. Wis., '71), Ph. D. (do., 76); *Berkeley, Cal.;* Asst. Prof. Chem., Univ. Miss., '72–'74; Asst. State Geol., Miss., '72–'74; do., Ga., '74–'78;

do., Ky., '82–'85; Prof. Agr. Chem., S. C. Coll., '85–'90; Asst. Prof. Agr. Chem. and Geol., Univ. Cal., '91–'08; Assoc. Prof., do., '08–'09; Emeritus Prof. Agr. Chem., do., '09—.

1901. THOMAS LYTTLETON LYON, B. S. A. (Cornell Univ., '91), Ph. D. (Gottingen, '94); *Ithaca, N. Y.;* Instr. Chem., Univ. Nebr., '91–'93; Asst. Chem., Nebr. Expt. Sta., '94–'95; Assoc. Prof. Agr., Univ. Nebr., '95–'99; Prof. Agr., do., and Assoc. Dir. Expt. Sta., '99–'06; Prof. Expt. Agron., Cornell Univ. and Expt. Sta., '06—.

1911. ARTHUR GILLETT MCCALL, B. S. Agr. (Ohio State Univ., '00); *Columbus, Ohio;* Asst., Bur. Soils, U. S. Dept. Agr., '00–'04; Asst. Prof. Agron., Ohio State Univ., '04–'05; Assoc. Prof. Agron., do., '05–'06; Prof. Agron., do., '06—.

1911. CHARLES EDWARD MARSHALL, Ph. B. (Univ. Mich., '95), Ph. D. (do., '02); *Amherst, Mass.;* Asst. Bact., Univ. Mich., '93–'96; do., Mich. Expt. Sta., '96–'98; Bct. and Hygienist, do., '98–'12; Sci. and Vice Dir., do., '08–'12; Prof. Bact. and Hyg., Mich. Agr. Coll., '03–'12; Dir. Graduate School and Prof. of Microbiol., Mass. Agr. Coll., '12—.

1911. FREDERICK RUPERT MARSHALL, B. S. Agr. (Ontario Agr. Coll., '99), B. S. A. (Iowa State Coll., '00); *Washington, D. C.;* Asst. Prof. Anim. Husb., Iowa State Coll., '01–'03; Prof. Anim. Husb., Tex. Agr. Coll., '03–'07; Prof. Anim. Husb., Ohio State Univ., '07–'12; Prof. Anim. Indus., Univ. Cal., and Anim. Husb., Cal. Expt. Sta., '12–'13; Senior Anim. Husb., Bur. Anim. Indus., U. S. D. A., '13—.

1911. DAVID WILLIAM MAY, B. Agr. (Univ. Mo., '94), M. Agr. (do., '96); *Mayaguez, P. R.;* Asst. Agr., Missouri Expt. Sta., '97; Sci. Asst. Office Expt. Stas., U. S. D. A., '00–'02; Anim. Husb., Ky. Expt. Sta., '02–'04; Special Agt. in Charge, P. R. Expt. Sta., '04—.

1905. LUCIUS HERBERT MERRILL, B. S. (Univ. Me., '83), D. Sc. (honorary, do., '08); *Orono, Me.;* Chem., Me. Expt. Sta., '86–'08; Prof. Biol. Chem., Univ. Me., '98–'07; Prof. Biol. and Agr. Chem., do., '07—.

1909. MERRITT FINLEY MILLER, B. S. Agr. (Ohio State Univ., '00), M. S. A. (Cornell Univ., '01); *Columbia, Mo.;* Asst. Bur. Soils, U. S. Dept. Agr., '01–'02; Instr. Agron., Ohio State Univ., '02–'03; Asst. Prof., do., '03–'04; Prof. Agron., and Agron., Univ. Mo. and Expt. Sta., '04—.

1910. GEORGE THOMAS MOORE, B. S. (Wabash Coll., '94), A. B. (Harvard Univ., '95), A. M. (do., '96), Ph. D. (do., '00); *Missouri Botanical Garden, St. Louis, Mo.;* in charge Bot. Dept., Dartmouth Coll., '99–'01; Physiol. and Algologist, Bur. Plant Indus., U. S. Dept. Agr., '01–'02; in charge

Lab. Plant Physiol., do., '02–'05; Prof. Plant Physiol. and Applied Bot., Shaw School of Bot., Mo. Bot. Gard., '09–'12; Dir., Mo. Bot. Gard., '12—.

1900. John Harcourt Alexander Morgan, B. S. A. (Univ. Toronto, '89); *Knoxville, Tenn.;* Prof. Ento. and Hort., La. State Univ., '89–'93; Prof. Zool. and Ento., do., '93–'04; Ento., La. Expt. Stas., '89–'04; Dir. Gulf Biol. Sta., '99–'05; Dir. Tenn. Expt. Sta., '05—.

1911. Fred Winslow Morse, B. S. (Worcester, '87), M. S. (do., '00); *Amherst, Mass.;* Asst. Chem., Mass. Expt. Sta., '87–'88; do., N. H. Expt. Sta., '88–'89; Chem., do., '89–'09; Vice Dir. do., '96–'09; Prof. Chem., N. H. Agr. Coll., '90–'09; Research Chem., Mass. Expt. Sta., '10—.

1912. Warner Jackson Morse, B. S. (Univ. Vt., '98), M. S. (do., '03), Ph. D. (Univ. Wis., '12); *Orono, Me.;* Teacher Nat. Sci., Montpelier Seminary, '99–'01; Asst. Bot., Vt. Expt. Sta., '01–'06; Instr. Bot., do., '01–'05; Asst. Prof. Bact., do., '05–'06; Plant Path., Me. Expt. Sta., '06—.

1909. Frederick Blackmar Mumford, B. S. (Mich. Agr. Coll., '91), M. S. (do., '93); *Columbia, Mo.;* Asst. Mich. Expt. Sta., '91–'95; Asst. Prof. Agr., Mich. Agr. Coll., '93–'95; Prof. Agr., Univ. Mo., '95–'04; Acting Dean Coll. Agr., Univ. Mo., and Acting Dir., Mo. Expt. Sta.' '03–'05; Prof. Anim Husb., Univ. Mo., '04—; in charge Anim. Husb. Dept., Mo. Expt. Sta., '06—; Dean Agr. and Dir. Expt. Sta., '09—.

1901. Herbert Windsor Mumford, B. S. (Mich. Agr. Coll., '91); *Urbana, Ill.;* Instr., Mich. Agr. Coll., and Asst., Expt. Sta., '95–'96; Asst. Prof. Agr. and Anim. Husb., do., '96–'99; Prof. Agr., do., '99–'01; Prof. Anim. Husb., Univ. Ill., and Chief in Anim. Husb., Ill. Expt. Sta., '01—.

1913. Martin Nelson, B. S. A. (Univ. Wis., '05), M. S. (do., '06); *Fayetteville, Ark.;* Adj. Prof. Field Crops and Soils Univ. Nebr. and Expt. Sta., '06–'07; Asst. Prof., do., '07–'08; Prof. Agron. and Agron., Univ. Ark. and Expt. Sta., '08–'13; Dean Univ. Ark. and Dir. Expt. Sta., '13—.

1893. Herbert Osborn, B. S. (Iowa State Coll., '79), M. S. (do., '80); *Columbus, Ohio;* Asst. Zool. and Ento., Iowa State Coll., '79–'83; Asst. Prof., do., '83–'85; Prof., do., '85–'98; Prof. Zool. and Ento., Ohio State Univ., '98—.

1893. Louis Herman Pammel, B. Agr. (Univ. Wis., '85), M. S. (do., '89), Ph. D. (Wash. Univ., '99); *Ames, Iowa;* Asst., Shaw School of Bot., '86–'89; Tex. Agr. Expt. Sta., '89; Prof. Bot., Iowa State Coll., '89—; Bot., Iowa Expt. Sta., '92—.

1893. Henry Jacob Patterson, B. S. (Pa. State Coll., '86); *College Park, Md.;* Asst. Chem., Pa. Expt. Sta., '86–'88;

Chem., Md. Expt. Sta., '88–'98; Dir. and Chem., do., '98; Pres. Md. Agr. Coll., '13—.

1910. RAYMOND PEARL, A. B. (Dartmouth Coll., '99), Ph. D. (Univ. Mich., '02); *Orono, Me.;* Asst. Zool., Univ. Mich., '99–'02; Instr. Zool., do., '02–'06; Instr. Zool., Univ. Penn., '06–'07; Biol. and Head Dept. Biol., Me. Expt. Sta., '07—; Assoc. Ed. *Zool. Jahresber,* '06–'08; *Biometrika,* '06–'10, *Zentbl. Allg. u. Expt. Biol.,* '10—.

1909. RAYMOND ALLEN PEARSON, B. S. A. (Cornell Univ., '94), M. S. A. (do., '99); *Ames, Iowa;* Asst. Chief Dairy Div., U. S. Dept. Agr., '95–'02; Mgr. Walker-Gordon Lab. Co., N. Y. and Phila., '02–'03; Prof. Dairy Ind., Cornell Univ., '03–'07; N. Y. Comr. Agr., '07–'12; Pres. Iowa State Coll., '12—.

1910. WILLIAM ROBERT PERKINS, B. S. (Miss. Agr. Coll., '91); M. S. (do., '94); *Deeson, Miss.;* Asst. State Chem., Miss., '91–'94; Chem., Miss., Expt. Sta., '94–'06; Asst. Prof. Agr., Miss. Agr. Coll., '06; Agron., Miss. Expt. Sta., '07–'10; Dir. Agr. Dept., and Prof. Agron., Clemson Coll., '10–'11; Supt. Syndicate Farm, Deeson, Miss., '11—.

1909. CHARLES VANCOUVER PIPER, B. S. (Univ. Wash., '85), M. S. (do., '92; Harvard, '00); *Washington, D. C.;* Prof. Ento., Wash. State Coll., '92–'93; Prof. Bot. and Zool., do., and Bot. and Ento., Expt. Sta., '93–'03; Syst. Agrostologist, U. S. Dept. Agr., '03–'04; Agrostologist, do., '05—.

1890. CHARLES SUMNER PLUMB, B. S. (Mass. Agr. Coll., '82); *Columbus, Ohio;* Asst. Ed. *Rural New Yorker,* '83–'84; First Asst., N. Y. Expt. Sta., '84–'87; Prof. Agr., Univ. Tenn., and Asst. Dir., Expt. Sta., '87–'90; Prof. Agr. Sci., Purdue Univ., '90–'94; Prof. Anim. Indus. and Dairying, do., '94–'00; Prof. Anim. Indus., do., '00–'02; Vice Dir., Ind. Expt. Sta., '90–'91; Dir., do., '91–'02; Prof. Anim. Indus., Ohio State Univ., '02—.

1894. FRANK WILLIAM RANE, B. Agr. (Ohio State Univ., '91), M. Sc. (Cornell Univ., '92); *State House, Boston, Mass.;* Hort. and Microscopist, W. Va. Expt. Sta., '92–'95; Prof. Agr. and Hort., W. Va. Univ., '93–'95; Prof. Agr. and Hort., N. H. Coll., '95–'98; Prof. Hort., do., '98–'00; Prof. Forestry and Hort., do., '00–'06; State Forester, Mass., '06—.

1913. JAMES BURNESS RATHER, B. S. (Tex. Agr. Coll., '07), M. S. (do., '11); *College Station, Tex.;* Asst. State Chem. Tex., '07–'09; Asst. Chem. Tex. Expt. Sta., '08–'12; First Asst. Chem., do., '12—.

1913. GEORGE MATTHEW REED, A. B. (Geneva Coll., '00), A. M. (Univ. Wis., '04), Ph. D. (do., '07); *Columbia, Mo.;* Prof. Nat. Sci., Amity Coll., '00–'03; Asst. in Bot., Univ. Wis.,

'04–'07; Instr. in Bot., do., '07; Asst. Prof. Bot., Univ. Mo., '07–'12; Prof. Bot., do., '12—; Bot. Mo. Expt. Sta., '09—.

1881. ISAAC PHILLIPS ROBERTS, M. Agr. (Iowa State Coll., '75); 731 Cameron Avenue, *Fresno, Cal.;* Prof. Agr. and Dean Agr., Cornell Univ., '73–'94; Dir. Cornell Expt. Sta., '88–'03; Dir. Col. Agr., '94–'03; Prof. Emeritus and lecturer, '03—.

1893. JAMES WILSON ROBERTSON, LL. D. (Toronto Univ., and Queen's Univ., '03; Univ. New Brunswick, '04); *Box 540, Ottawa, Can.;* Prof. Dairying, Ontario Agr. Coll., '86–'90; Dairy Comr. Canada, '90–'95; Comr. Agr. and Dairying, '95–'04; Prin., MacDonald Coll., '05–'09; Chairman Royal Com. on Indus. Training and Tech. Ed., '10—.

1909. PETER HENRY ROLFS, B. S., M. S. (Iowa State Coll., '91); *Gainesville, Fla.;* Asst. Bot., Iowa State Coll., '91; Ento. and Bot., Fla. Expt. Sta., '92–'98; Bot. and Hort., do., '98–'99; Bot. and Bact., S. C. Expt. Sta., '99–'01; Plant Path. in charge Sub-Trop. Lab., U. S. Dept. Agr., Miami, Fla., '01–'06; Dir., Fla. Expt. Sta., '06—; State Supt. Farmers' Institutes, '07—.

1911. GEORGE McCULLOUGH ROMMEL, B. S. (Iowa Wesleyan Univ., '97), B. S. A. (Iowa State Coll., '99); *Washington, D. C.;* Expert in Anim. Husb., Bur. Anim. Indus., U. S. Dept. Agr., '01–'05; Anim. Husb., do., '05–'09; Chief, Anim. Husb. Div., do., '10—.

1909. HARRY LUMAN RUSSELL, B. S. (Univ. Wis., '88), M. S. (do., '90), Ph. D. (Johns Hopkins, '92); *Madison, Wis.;* Fellow Univ. Wis., '88–'90; Fellow Univ. Chicago, '92–'93; Asst. Prof. Bact., Univ. Wis., '93–'96; Prof. do., '96–'97; Bact., Wis. Expt. Sta., '93–'97; Dir. State Hygienic Lab., '03–'07; Dean Coll. of Agr. and Dir. Expt. Sta., Univ. Wis., '07—.

1912. WALTER GEORGE SACKETT, B. S. (Univ. Chicago, '02); *Fort Collins, Col.;* Prof. Nat. Sci., Meredith Coll., '02–'04; Special Agt., U. S. Dept. Agr., '04; Instr. Bact. and Hyg., Mich. Agr. Coll., '04–'06; Asst. Prof. Bact. and Hyg., do., and Asst. Bact. Mich. Expt. Sta., '06–'08; Bact., Col. Expt. Sta., '08—.

1908. EZRA DWIGHT SANDERSON, B. S. (Mich. Agr. Coll., '97), B. S. Agr. (Cornell, '98); *Morgantown, W. Va.;* Asst. State Ento. Md., '98–'99; Ento., Del. Expt. Sta., and Assoc. Prof. Zool., Del. Coll., '99–'02; State Ento. Tex., and Prof. Ento., Tex. A and M. Coll., '02–'04; Ento., N. H. Expt. Sta., and Prof. Ento. and Zool., N. H. Coll., '04–'09; Dir. N. H. Expt. Sta., '07–'09; Dean Coll. Agr., W. Va. Univ., '10—; Dir., W. Va. Expt. Sta., '12—.

1910. ROBERT SIDEY SHAW, B. S. (Ontario Agr. Coll., '93); *East*

Lansing, Mich.; Asst. Agr., Mont. Agr. Coll. and Expt. Sta., '97–'02; Prof. Agr., Mich. Agr. Coll., '02–'08; Dean Agr., do., and Dir. Expt. Sta., '08—.

1893. THOMAS SHAW, *2135 Knapp Street, St. Paul, Minn.;* Prof. Agr., Ontario Agr. Coll., '88–'93; Prof. Anim. Husb., Minn. Coll. Agr., '93–'03; Ed. *Farmer,* '03–'08; Northwest Ed. Orange Judd Publications '08—.

1898. JOHN HENRY SHEPPERD, B. Agr. (Iowa State Coll., '91), M. S. A. (Univ. Wis., '93); *Agricultural College, N. Dak.;* Ed. Staff *Orange Judd Farmer,* '93; Prof. Agr., N. Dak. Agr. Coll., and Agriculturist Expt. Sta., '93–'04; Dean and Vice Dir., do., '04—.

1909. JOHN HARRISON SKINNER, B. S. (Purdue Univ., '97); *Lafayette, Ind.;* Asst. Agr., Ind. Expt. Sta., '99–'01; Instr. Anim. Husb., Univ. Ill., '01–'02; Assoc. Prof. Anim. Husb., Purdue Univ., '02–'06; Prof., do., '06; Dean Agr. Dept., Purdue Univ., '07—.

1907. CLINTON DEWITT SMITH, M. S. (Cornell Univ., '75); *Trumansburg, N. Y.;* Dir. Ark. Expt. Sta., '90; Dir. Minn. Sta., and Prof. Dairy Husb., Univ. Minn., '90–'93; Dir. Mich. Expt. Sta. and Prof. Agr., '93–'08; Dir. and Dean Spec. Course, Mich. Agr. Coll., '99–'08; Dir. Escola Agricola Practica, '08–'12; Farmer and Lecturer, '12—.

1907. HOWARD REMUS SMITH, B. Sc. (Mich. Agr. Coll., '95); *University Farm, St. Paul, Minn.;* Teacher, Tilford Collegiate Acad. and Rock Island High School, '95–'09; Acting Prof. Agr., Univ. Mo., '00–'01; Asst. Prof. Anim. Husb., Univ. Nebr., '01; Assoc. Prof., do., '02; Prof., do., '03–'12; Anim. Husb., Univ. Minn., '12—.

1899. HARRY SNYDER, B. S. (Cornell Univ., '89); *1800 Summit Ave., Minneapolis, Minn.;* Asst. Chem., Cornell Univ. Expt. Sta., '90–'91; Asst. Instr. Qual. Anal., do., '89–'90; Prof. Agr. Chem., Univ. Minn., and Chem., Expt. Sta., '91–'09; Chem., Russell Miller Milling Co., '09—.

1909. ANDREW MCNAIRN SOULE, B. S. (Univ. Toronto, '93), Sc. D. (honorary, Univ. Ga., 10); *Athens, Ga.;* Asst. Dir., Mo. Expt. Sta., '94; Asst. Prof. Agr. and Asst. Agriculturist, Tex. Agr. Coll. and Expt. Sta., '94–'99; Dir. Tenn. Expt. Sta. and Chairman Agr. Faculty, Univ. Tenn., '99–'04; Dean of Agr. and Dir. Expt. Sta., Va. Poly. Inst., '04–'07; Pres. Coll. Agr. Univ. Ga., '07—.

1903. WILLIAM JASPER SPILLMAN, B. S. (Univ. Mo., '86), M. S. (do., '89), Sc. D. (do., '10); *Washington, D. C.;* Prof. Sci., Mo. State Normal, '87–'89; Prof. Sci., Vincennes Univ., '89–'91; Prof. Sci., Ore. State Normal, '91–'94; Prof. Agr., State Coll. Wash., '94–'01; Agrostologist, U. S. Dept. Agr., '01–'04; Agriculturist in charge Farm Management, do., '04—.

1911. Frank Lincoln Stevens, B. L. (Hobart, '91), B. S. (Rutgers Coll., '93), M. S. (do., '97); Ph. D. (Univ. Chicago, '00), *Urbana, Ill.;* Teacher of Sci., Racine Coll., '93–'94; do., Columbus, O., High School, '94–'97; Instr. in Biol., N. C. Agr. Coll., '00–'02; Prof. Bt. and Veg. Path., do., '03–'11; Biol., N. C. Expt. Sta., '03–'11; Dean, P. R. Coll. Agr., '12–'14; Prof. Plant Path., Univ. Ill., '14—.

1908. William Alton Taylor, B. S. (Mich. Agr. Coll., '88), D. Sc. (do., '13); *Washington, D. C.;* Asst. Pomol., U. S. Dept. Agr., '91–'01; Pomol. in charge Field Investigations, '01–'10; Asst. Chief, Bur. Plant Indus., '11–'13; Chief, do., '13—.

1911. Roscoe Wilfred Thatcher, B. Sc. (Univ. Nebr., '98), M. A. (do., '01); *University Farm, St. Paul, Minn.;* Asst. Chem., Nebr. Expt. Sta., '99–'01; Asst. Chem., Wash. Expt. Sta., '01–'03; Chem., do., '03–'12; Asst. Prof. Chem., State Coll. Wash., '04–'06; Assoc. Prof., do., '06–'10; Prof. Agr. Chem. and Head of Dept. Agr., do., '10–'13; Dir. Wash. Expt. Sta., '07–'13; Prof. Agr. Chem. and Agr. Chem., Univ. Minn. and Expt. Sta., '13—.

1907. Charles Embree Thorne, M. Agr. (Ohio State Univ., '90); *Wooster, Ohio;* Dir. Ohio Expt. Sta., '87—.

1910. Edward Gaige Titus, B. S. (Col. Agr. Coll., '99); M. S. (do., '01), D. Sc. (Harvard, '11); *Logan, Utah;* Asst. Dept. Zool. and Ento., Col. Agr. Coll., '00–'01; Field Asst. State Ento., Ill., '01–'03; Spec. Agt., Bur. Ento., U. S. Dept. Agr., '03–'07; Prof. Zool. and Ento., Utah Agr. Coll. and Ento., Expt. Sta., '07—.

1901. Charles Orrin Townsend, B. S. (Univ. Mich., '88); M. S. (do., '91), Ph. D. (Leipsic, '97); *Garden City, Kans.;* Prof. St. Johns Coll., Md.; '88–'91; Prof. Sci., Wesleyan Coll., Ga., '91–'95; Instr. Bot., Barnard Coll., '98; Prof. Bot., Md. Agr. Coll., and State Plant Path. Md., '98–'01; Path. Bur. Plant Indus., U. S. Dept. Agr., '01–'10; do., '12—; Consulting Agr., U. S. Sugar and Land Co., '10–'12.

1881. Samuel Mills Tracy, B. A. (Mich. Agr. Coll., '68), M. S. (do., '76); *Biloxi, Miss.;* Asst. Prof. Agr., Mo. State Univ., '77–'80; Prof. Bot. and Hort., do., '80–'87; Dir. Miss. Expt. Sta., '87–'97; Spec. Agt. U. S. Dept. Agr., '97—.

1894. William Trelease, B. S. (Cornell, '80), D. Sc. (Harvard, '84), LL. D. (Wis., '02; Mo., '03; Wash. Univ., '07); *Urbana, Ill.;* Prof. Bot., Univ. Wis., '83–'85; Engelmann Prof. Bot. and Dir. Shaw School Bot., Wash. Univ., '85—; Dir. Mo. Bot. Gard., '89–'12; Research Work, '12–'13; Prof. Bot., Univ. Ill., '13—.

1913. Perry Fox Trowbridge, B. Pd. (Mich. Norm. Coll., '92), Ph. B. (Univ., Mich., '92), A. M. (do., '05), Ph. D. (Univ.

Ill., '06), M. Pd. (Mich. Norm. Coll., '11); *Columbia, Mo.;* Instr. Chem., Univ. Mich., '94–'02; Sugar Chem., do., '02–'05; Research Asst. and Instr. in Chem., Univ. Ill., '05–'07; Agr. Chem. and Assoc. Chem., Univ. Mo. and Expt. Sta., '07–'08; Prof. and Chem., do., '08—.

1907. ALFRED CHARLES TRUE, B. A. (Wesleyan Univ., '73), M. A. (do., '76), Ph. D. (Erskine Coll., S. C., '86); D. Sc. (Wesleyan Univ., '06); *Washington, D. C.;* Prin. High School, Essex, N. Y., '73–'75; Instr. State Normal School, Westfield, Mass., '75–'82; Grad. Stud., Harvard Univ., '82–'84; Instr., Wesleyan Univ., '84–'88; Ed., U. S. Office Ext. Stas., '88–'91; Asst. Dir., do., '91–'93; Dir., do., '93—.

1914. HUBERT EVERETT VAN NORMAN, B. S. (Mich. Agr. Coll., '97); *Davis, Calif.;* Mgr. Dairy Farm, '97–'98; Supt. Univ. Farm, Purdue Univ., '98–'02; Chief, Dairy Dept., Purdue Univ., '02–'05; Prof. Dairy Husb., Pa. St. Coll., '05–'13; Prof. Dairy Mgmt., Univ. of Calif., '13—; Vice-Dir., Agr. Expt. Sta. and Dean, Univ. Farm School, '13—; Sec. Ind. Dairy Ass'n, '98–'05; Sec. Pa. Dairy Union, '06–'13; Pres. Nat. Dairy Show, '10—.

1908. ALFRED VIVIAN, Ph. G. (Univ. Wis., '94); *Columbus, Ohio;* Instr. Phar., Univ. Wis., '94–'95; Asst. Agr. Chem., do., '95–'97; Instr., do., and Asst. Chem., Expt. Sta., '97–'02; Assoc. Prof. Agr. Chem., Ohio State Univ., '02–'05; Prof. Agr. Chem., do, '05—.

1912. JOHN FRANCIS VOORHEES, B. S. A. (Univ. Tenn., '09), M. S. A. (do., '11), *Knoxville, Tenn.;* Asst. Observ., U. S. Weather Bur., New Orleans, La., '01; do., Knoxville, Tenn., '02–'05; Observ. in charge Knoxville Sta., '06—; Instr. in Met. and Consult. Met., Univ. Tenn. and Expt. Sta., '09—.

1893. HENRY JACKSON WATERS, B. Agr. (Univ. Mo., '86); *Manhattan, Kans.;* Asst. Agr., Mo. Expt. Sta., '87–'91; Prof. Agr., Pa. State Coll., '92–'95; Dean Coll. Agr. and Dir. Expt. Sta., Univ. Mo., '96–'09; Pres., Kans. State Agr. Coll., '09—.

1914. RALPH LEVI WATTS, B. A. (Pa. State Coll., '90); M. S. (do., '99); *State College, Pa.;* Hort. of Tenn. Expt. Sta., '90–'99; Lecturer, Farmers Institutes, Pa., Md., N. J., '99–'08; Prof. of Hort., Pa. St. Coll., '08–'12; Actg. Dean and Dir. School of Agr. and Expt. Sta., Pa. St. Coll., '12–'13; Dean and Dir. (do.), '13—.

1910. HERBERT JOHN WEBBER, B. Sc. (Univ. Nebr., '89); M. A. (do., '90), Ph. D. (Wash. Univ., St. Louis, '00); *Riverside, Cal.;* Asst. in Bot., Univ. Nebr., '89–'90; Asst., Shaw School of Bot., '90–'92; Physiol., U. S. Dept. Agr., '92–'97; in charge Plant Breeding Lab,, do., '97–'07; Prof. Expt.

Plant Breeding, Cornell Univ., '07–'12; Dir., Citrus Expt. Sta., and Dean, Grad. School Trop. Agr., Univ. Cal., '13—.

1889. CLARENCE MOORE WEED, B. S. (Mich. Agr. Coll., '83), M. S. (do., '84), D. Sc. (Ohio State Univ., '89); *Lowell, Mass.;* Asst. State Ento., Ill., '86–'88; Ento., Ohio Expt. Sta., '88–'91; Prof. Zool. and Ento., N. H. Coll., and Ento., Expt. Sta., '91–'04; Nature Study Work, State Normal School, Lowell, Mass., '04—.

1896. JULIUS BUELL WEEMS, B. Sc. (Md. Agr. Coll., '88), Ph. D. (Clark Univ., '94); *South Boston, Va.;* Instr. Chem. and Math., Md. Agr. Coll., '88–'89; Con. Chem., do., '91–'92; Prof. Agr. Chem. and Chem. Expt. Sta., Iowa State Coll., '95–'04; Industrial Chem., '04—.

1904. HOMER JAY WHEELER, B. Sc. (Mass. Agr. Coll. and Boston Univ., '83), Ph. D. (Univ. Göttingen, '89), D. Sc. (Brown, '11); *92 State St., Boston, Mass.;* Asst. Chem., Mass. Expt. Sta., '83–'87; Chem., R. I. Expt. Sta., '89–'08; Prof. Geol., R. I. Coll., '89–'12; Prof. Agr. Chem., do., '03–'10; Acting Pres., do., '02–'03; Dir. Expt. Sta., do., '01–'12, Agron., do., '05–'12; Expert, Amer. Agr. Chem. Co., '12—.

1889. MILTON WHITNEY, *Washington, D. C.;* Asst. Chem., Conn. Expt. Sta., '83; Supt. Expt. Farm, N. C. Expt. Sta., '86–'88; Prof. Agr., S. C. Coll., and Vice Dir. Expt. Sta., '88–'91; Soil Physicist, Md. Expt. Sta., '91–'94; Prof. Soil Physics, Md. Agr. Coll., '94–'01; Chief Bur. Soils, U. S. Dept. Agr., '94—.

1898. JOHN CHARLES WHITTEN, B. S. (S. Dak. Agr. Coll., '91), M. S. (do., '99), Ph. D. (Univ. Halle, '02); *Columbia, Mo.;* Instr. in Hort. and Hort. Expt. Sta., S. Dak. Agr. Coll., '92; Asst. in Hort., Mo. Bot. Gard., '93–'94; Prof. Hort. and Hort. Expt. Sta., Univ. Mo., '94—.

1911. JOHN ANDREAS WIDTSOE, B. S. (Harvard Univ., '94), Ph. D. (Univ. Göttingen, '99); *Logan, Utah;* Chem., Utah Expt. Sta., '94–'05; Prof. Chem., Utah Agr. Coll., '95–'05; Dir. Utah Expt. Sta., '00–'05; Dir. School of Agr., Brigham Young Univ., '05–'07; Pres., Utah Agr. Coll., '07—.

1908. HARVEY WASHINGTON WILEY, A. B. (Hanover, '67), M. D. (Indiana Med. Coll., '71), B. S. (Harvard, '73), Ph. D. (Hanover, '76), LL. D. (do., '98); *Washington, D. C.;* Prof. Chem., Butler, '73–'74; Prof. Chem., Purdue Univ., '74–'83; State Chem., Ind., '81–'83; Chief, Div. Chem., U. S. D. A., '83–'01; Chief Bur. Chem., do., '01–'12; Writer and Lecturer, '12—.

1912. JULIUS TERRASS WILLARD, B. S. (Kans. Agr. Coll., '83), M. S. (do., '86), D. Sc. (do., '08); *Manhattan, Kans.;* Asst. in Chem., Kans. Agr. Coll., '83–'87; Asst. Prof. Chem., do., '90–'96; Assoc. Prof. Chem., do., '96–'97; Prof.

Appl. Chem., do., '97–'01; Prof. Chem., do., '01—; Dean, Div. Gen. Sci., do., '09—; Asst. Chem., Kans. Expt. Sta., '88–'97; Chem,. do., '97—; Dir., do., '00–'06; Chem., Kans. Engin. Expt. Sta., '10—.

1912. CHARLES BURGESS WILLIAMS, B. S. (N. C. Agr. Coll., '93), M. S. (do., '96); *West Raleigh, N. C.;* Asst. Chem., N. C. Dept. Agr., '93–'06; Agron., do., '06–'07; Dir. and Agron., N. C. Expt. Sta., '07–'12; Vice Dir. and Agron., do., '13—.

1908. CARLOS GRANT WILLIAMS, *Wooster, Ohio;* Agron., Ohio Expt. Sta., '03—.

1911. WILLIAM ALPHONSO WITHERS, A. B. (Davidson Coll., '83), A. M. (do., '85); *West Raleigh, N. C.;* Asst. Chem., N. C. Expt. Sta., '84–'88; Prof. Chem., N. C. Agr. Coll., '89—; Statis. Agt., U. S. Dept. Agr., '95–'02; Acting Dir., N. C. Expt. Sta., '97–'99; Chem., do., '97—.

1909. FRITZ WILHELM WOLL, B. S. (Royal Frederiks Univ., Christiana, '82), Ph. B. (do., '83), M. S. (Univ. Wis., '86), Ph. D. (do., '04); *Davis, Cal.;* Asst. Chem., Wis. Expt. Sta., '87–'97; Chem., do., '97–'13; Asst. Prof. Agr. Chem., Univ. Wis., '93–'04; Assoc. Prof., do., '04–'06; Prof., do., '06–'13; Prof. Anim. Nutr., Univ. Cal. and Expt. Sta., '13—.

1903. ALBERT FREDERICK WOODS, B. Sc. (Univ. Nebr., '90), A .M. (do., '92), D. Agr. (do., '13); *University Farm, St. Paul, Minn.;* Asst. Bot., Univ. Nebr., '91–'94; Asst. Chief Div. Veg. Path., U. S. Dept. Agr., '94–'00; Chief, do., '01–'09; Asst. Chief, Bur. Plant Indus., do., '01–'09; Dean Coll. of Agr., Univ. Minn., and Dir. Expt. Sta., '10—.

1903. CHARLES DAYTON WOODS, B. S. (Wesleyan Univ., Conn., '80), D. Sc. (honorary, Univ. Me., '05); *Orono, Me.;* Asst., Chem., Wesleyan Univ., '80–'85; Instr. Sci., Wilbraham Acad., Mass., '83–'88; Chem., Conn. Storrs Expt. Sta., '88–'96; Vice Dir., do., '89–'96; Prof. Agr., Univ. Me., '86–'03; Dir. Maine Expt. Sta., '96—.

1911. BONNEY YOUNGBLOOD, B. S. (Tex. Agr. Coll., '02), M. S. (do., '07); *College Station, Tex.;* Prin. and Instr. in Agr., Henderson, Tex., City Schools, '03–'05; Prin. and Instr. in Agr., Mineola, Tex., High School, '05–'06; Supt. City Schools and Instr. in Agr., Pauls Valley, Okla., '06–'07; Asst. Agr., Office of Farm Management, U. S. Dept. Agr., '07–'11; Dir., Tex. Expt. Sta., '11—.

1910. C. A. ZAVITZ, B. Sc. (Toronto Univ., '88); *Guelph, Canada;* Asst. Expt. Dept., Ontario Agr. Coll., '86–'93; Head of Expt. Dept., '93—; Prof. of Field Husbandry, Ontario Agr. Coll., '04—.

DECEASED MEMBERS.

Robert Fairchild Kedzie,	Born	Dec. 9, 1852	Died	Feb. 13, 1882
Lauren Briggs Arnold,	"	Aug. 13, 1814	"	Mar. 7, 1888
George Hammel Cook,	"	Jan. 5, 1818	"	Sept. 22, 1889
Patrick Barry,	"	May 24, 1816	"	June 24, 1890
John J. Thomas,	"	Jan. 8, 1818	"	Feb. 22, 1895
Charles Valentine Riley,	"	Sept. 18, 1843	"	Sept. 14, 1895
Charles Lee Ingersoll,	"	Nov. 1, 1844	"	Dec. 15, 1895
Edward Louis Sturtevant,	"	Jan. 23, 1842	"	July 30, 1898
Sir John B. Lawes, *Hon. Mem.*,	"	Dec. 28, 1814	"	Aug. 31, 1900
John Alvah Myers,	"	May 29, 1853	"	April 8, 1901
Sir Henry Gilbert, *Hon. Mem.*,	"	Aug. 1, 1817	"	Dec. 23, 1901
Robert Clark Kedzie,	"	Jan. 28, 1883	"	Nov. 27, 1902
Victor Hunt Lowe,	"	Sept. 23, 1869	"	Aug. 27, 1903
Henry English Alvord,	"	Mar. 11, 1844	"	Oct. 1, 1905
Robert Warington, *Hon. Mem.*,	"	Aug. 22, 1838	"	Mar. 20, 1907
Willis Grant Johnson,	"	July 4, 1866	"	Mar. 11, 1908
James Fletcher,	"	Mar. 28, 1852	"	Nov. 8, 1908
Samuel William Johnson,	"	July 3, 1830	"	July 21, 1909
William Henry Brewer,	"	Sept. 14, 1828	"	Nov. 2, 1910
Charles Anthony Goessmann,	"	June 13, 1827	"	Sept. 1, 1910
Samuel B. Green,	"	Sept. 15, 1859	"	July 11, 1910
Welton M. Munson,	"	April 8, 1866	"	Sept. 9, 1910
Edward Burnett Voorhees,	"	June 22, 1856	"	June 6, 1911
Franklin Hiram King,	"	June 8, 1848	"	Aug. 4, 1911
Oskar Kellner, *Hon. Mem.*,	"	May 13, 1851	"	Sept. 22, 1911
John Bernhardt Smith,	"	Nov. 21, 1858	"	Mar. 12, 1912
Melville Amasa Scovell,	"	Feb. 26, 1855	"	Aug. 15, 1912
Charles Edwin Bessey,	"	May 21, 1845	"	Feb. 25, 1915

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OF THE

THIRTY-SIXTH ANNUAL MEETING

OF THE

Society for the Promotion of Agricultural Science

HELD AT

BERKELEY, CALIFORNIA

AUGUST 9 AND 10, 1915

EDITED BY THE SECRETARY

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OFFICERS OF THE SOCIETY FOR 1916.

President . . . . . CHARLES E. THORNE, Wooster, Ohio.

Vice-President . . HERBERT OSBORN, Columbus, Ohio.

Secretary-Treasurer . . L. A. CLINTON, U. S. Department of Agriculture, Washington, D. C.

Custodian . . . . W. D. HURD, Amherst, Mass.

Executive Committee .
- C. D. WOODS, Orono, Maine.
- DAVID FAIRCHILD, Washington, D. C.
- W. H. JORDAN, Geneva, N. Y.

THIRTY-SIXTH ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF AGRICULTURAL SCIENCE.

The thirty-sixth annual meeting of the Society for the Promotion of Agricultural Science convened at Berkeley, California, Monday afternoon, August 9, at 2 o'clock. J. T. Willard, of Kansas, was elected temporary chairman. A motion was made and carried that owing to the various other meetings which were in progress we adjourn until the evening session.

The evening session was a joint session of the Society for the Promotion of Agricultural Science, the American Society of Agronomy, and the American Farm Management Association. The program consisted of addresses by the presidents of these various societies. At the Tuesday morning session, with President Waters in the chair, the first paper was presented by R. W. Thatcher as announced in the program. At the time of the presentation of the paper by Professor I. P. Roberts the various other societies adjourned to hear his paper.

Committees were appointed as follows: Auditing Committee, W. D. Hurd, J. T. Willard, and R. W. Thatcher; Committee on Nominations, C. D. Woods, F. W. Woll, and L. H. Pammell.

A motion was made and carried that the invitation to the Society to be represented by delegates at the Pan-American Scientific Congress to be held at Washington, D. C., be referred to the Executive Committee with power to act.

The nominating committee reported as follows: For President, C. E. Thorne, Wooster, Ohio; Vice-President, Herbert Osborn, Columbus, Ohio; Secretary-Treasurer, L. A. Clinton, Washington, D. C.; Custodian, W. D. Hurd, Amherst, Mass.; member of Executive Committee, C. D. Woods, Orono, Maine. The report of the Committee was accepted and the men as nominated were duly elected to office. The following names were presented and elected to membership:

J. H. Kastle, Lexington, Kentucky; W. L. Carlyle, Stillwater, Oklahoma; J. S. Jones, Moscow, Idaho; Thomas P. Cooper, Fargo, North Dakota.

The Auditing Committee reported that the Treasurer's books had been examined, the accounts found correct and the cash balance was $320.17. The report of the Auditing Committee was accepted. A motion was made and carried that fifty copies of separates for authors be printed at the expense of the Society.

THE ELEMENTS OF AN IDEAL RURAL CIVILIZATION.

THE PRESIDENT'S ANNUAL ADDRESS.

By H. J. Waters,
Kansas Agricultural College.

Thirty-six years ago, when the Society for the Promotion of Agricultural Science was organized, the difficulties of agricultural production were very much greater than they now are. Improved machinery, by the use of which man's efficiency in production has been increased four-fold, was just coming to be generally used. While it had been known since before the beginning of the Christian Era that the growing of legumes exerted a beneficial effect upon the soil, yet in just what way this beneficial effect was produced had not been discovered. Insect pests and plant diseases had accumulated to such an extent as to cause great injury, yet their life histories had not been worked out and the means by which they might be controlled were not known. The farmer then was almost as helpless in the face of a scourge of blackleg, hog cholera, or Texas fever as were the farmers in the time of the Egyptian civilization.

Up to this time it had required all the knowledge and skill that the farmers could command or the most learned men could dispense, to produce the material necessary to ward off famine from one harvest to another. The world still lived from hand to mouth and famine, though less frequent than in former years, was still a most serious menace.

EXPANDING PRODUCTION.

With the universal use of labor-saving machinery, with the bringing of the great prairies under the plow, with the substitution of coal for wood and of the locomotive for the

ox team, food enough to satisfy the wants of everybody was produced. Almost without warning a new condition was created. Food enough could be had to satisfy the needs of the body without slaving constantly to produce it. There was leisure for the laboring class, and time, and the means with which to develop the broader cultures of life.

Young people went to college from walks of life which had not before furnished college students. Men sprang from long lines of obscure ancestors into positions of leadership in the world's greatest affairs. Ideal conditions these were for the development of a higher and richer civilization. Art, literature, science, and education flourished because the masses could spare time from their struggle for existence in which to patronize them.

We prided ourselves on the fact that, though we were the youngest nation on earth, we had brought about this ideal condition, and we foolishly believed it would be permanent. Yet within less than two and a half decades we have seen the price of food stuffs rise from the lowest point known in history to the highest point. Not that production has failed; it has merely halted in its progress. But the world had been quick to absorb the increased production in higher standards of living. Consumption did not halt in its progress, but grew faster than production, and soon the era of surplus food, the era of low cost of living, was at an end.

In this era of low cost of living, brief and transitory as it was, there grew up profligate wastes in our ways of living and of conducting business. These wastes we have not yet succeeded in stopping, not even in checking. Also we are bringing into this second, and so far as we know permanent, era of high cost of living, educated tastes and costly desires.

A CIVILIZATION THAT TAXES OUR RESOURCES.

To support, therefore, even the world's present civilization, without allowing for further development, will tax

our resources and ingenuity as they have been taxed by no other civilization. In America, in particular, much of the development of which we like to boast, has been produced at the expense of our permanent capital. The resources of soil, mine, forest, and stream, have been drawn upon to a greater extent during this period than at any previous time. Disregarding this item, and it is a large and an important one, the nations have not lived within their income.

In spite of the greatest prosperity the world has ever known, public indebtedness has increased by leaps and bounds. Before the present war began, the nations of the world were overdrawn nearly forty billion dollars, the cities owed twenty billion more,—a national and municipal indebtedness that would require all the wealth of Great Britain or half the wealth of the United States to discharge. Pawn checks these, which we complacently pass on to our children for payment and our children must make the money with which to meet these obligations, and the many billions of dollars of new indebtedness already created by the present war, out of mines which have already been heavily worked, out of soils which are in need of rest and repair, and out of forests which they must first reëstablish. Desires have been created which our present methods of production cannot satisfy. Ambitions have been aroused which cannot be realized. Either we must strengthen production or slow down in our progress toward better standards of living.

MEANS OF FURTHER EXPANDING PRODUCTION.

There are two ways in which production may be quickly and greatly increased; by increasing the area under the plow and by increasing the acre-yield of the land now being tilled. According to a recent report of the United States Department of Agriculture only twenty-eight per cent. of the arable land of this country has yet been brought under the plow. It would seem, therefore, that there were possi-

bilities enough in this direction alone to satisfy all our demands for many years to come.

But we must understand that the land now in cultivation is the best land we have, is located most conveniently to markets, and is where the climate is most suitable for farming, and where conditions of living are most satisfactory. The land not yet in cultivation is the least productive of our tillable land, or is located where conditions of living are less satisfactory, or where floods or droughts are of frequent occurrence.

The labor cost of production then on the land yet remaining untilled will be much greater than it is on the land now in cultivation and this land will come into use slowly and only as the demand for food increases. Society will have to pay more in the future for its food in order to force this land into use, or else the farmer will have to take less for his labor when he tills this indifferent land.

ACRE-YIELD AND FAMILY INCOME.

It is true that the twenty-eight per cent. we till is tilled very indifferently and is made to produce far less than it is capable of producing. The acre-yield may be increased materially by more intelligent rotation of crops, better conservation of moisture, plowing and tilling the land at more opportune times, and the use of better seed and better live stock. Such increases cost much less than they are worth and are therefore very profitable. Beyond this point, however, the increase in acre-yield is accomplished with a substantial outlay of labor and money, through deeper plowing, more frequent tillage, irrigation, and the use of expensive manures and fertilizers. High yields are apt to be accompanied by large expenditures. Doubling the acre-yield is not, as most people suppose, the means of doubling the net returns to the farmers. The extent to which high production may be carried with profit is dependent largely upon the market price of the crop produced.

Intensive farming, therefore, is not the simple and easily

applied remedy for all our present ills. It is a system of farming which is adapted only to conditions where land is high and labor is cheap. It is essentially hand farming. It does not employ much farm machinery, or other labor-saving devices. It produces comparatively little livestock and has not afforded an income sufficient to provide many conveniences for the farm home.

Intensive farming developed to a moderate degree has produced the peasant class of Europe, "the man with the hoe." In Saxony, Belgium, and Brittany, where intensive agriculture is more highly developed than elsewhere in Europe, the farm woman frequently serves as a draft animal and is hitched alongside a dog. Carried to its full limit, intensive farming has produced the Chinese and Japanese farmers, the type that can out-labor and under-live any other type of farmer in the world.

Extensive agriculture develops the highest form of rural civilization because it gives an income above the actual physical needs of the family. It affords the means of procuring the broader cultures of life. It is the kind of agriculture that uses much machinery and raises much live stock and these in themselves develop the highest type of husbandman.

Business men have been thinking too seriously of acre-yield, and have not considered the effect it may have upon the family income and upon rural people. To illustrate, the income from all sources for all the land under cultivation in Japan is $71.00 an acre; in the United States, $15.00, and in Kansas, $13.50. Yet the yearly income of the average farm family of Japan is $235.00; of the United States, $1,000.00; and of Kansas, $1,560.00.

So long, therefore, as society is not made to suffer undue hardships on account of the high cost of living, a reasonably extensive system of agriculture is best for everybody. So long as a country can get along with farms of reasonable size, it is inadvisable to try to force upon that country an intensive type of farming. Indeed, no country has ever adopted this type of farming until forced to do so by the

demands of a part of their people for an opportunity to work and of all the people for food.

THE FARMER A BUSINESS MAN.

I do not wish to be understood as suggesting that the farmer establish a corner in food products, or as counselling an agricultural trust even as a means of fighting other trusts. The farmer must not loaf on his job. But he is entitled to a reasonable return on his investment of capital and labor. Indeed, he is entitled to a return that will class him among the business men of the world and not as a common laborer, for the average investment of land and equipment of the farmers of the United States is nearly $8,000.00. He should have a return on this investment that will support his family as well as does the business man in town who conducts an enterprise of similar magnitude and importance. The farmer's income should be such as to enable him to contribute as much toward the support of the schools, churches, roads, and household conveniences as do the proprietors of grocery stores, drug shops, meat markets, and dry-goods stores.

SOCIETY MUST MAKE SACRIFICES.

It is true that society has always determined the conditions under which it will be fed. The man on the farm thus far has had little to say regarding the terms under which he will discharge the task of feeding and clothing the world. Today society demands cheap food, and, insofar as it may be provided without imposing burdens upon future generations through the waste of our resources, and without imposing undue burdens upon the people on the land, the demand is a reasonable one. Low cost of living, however, bought with our permanent capital, is temporary and wasteful. Low cost of living purchased with the manhood and womanhood of the rural communities is dearly bought and destructive of our best asset. If we

satisfy this demand of society, therefore, without regard to its effect upon our rural civilization, we shall repeat the fundamental mistake of the nations and civilizations which have preceded us, and in the end will reduce the American farmer to the level of a peasant.

THE BROADENING SCOPE OF AGRICULTURAL SCIENCE.

Thus the problems of production, though greatly simplified through invention and scientific discovery, are still pressing and paramount and the work yet to be done along this line is of no less importance than that which has already been accomplished. But the science of agriculture has been greatly broadened within recent years. Now, in addition to the details of production, it has to do with all phases of transporting and marketing the products and the utilizing of the income arising from the farm business in creating and supporting the right sort of family life.

A society organized to promote agricultural science must be ready to throw the weight of its influence against all false doctrines in agriculture, whether they relate to farm crops or farm people. Such a society must help the city people to think straight along the lines affecting the welfare of the rural people as well as to protect the rural people from heresies which stand in the way of their progress.

It must be kept clearly in mind that the blight of a rundown rural stock is even greater than is the blight of a wasted soil; for the first essential of a permanent agriculture is an intelligent and stable rural people. Under no other condition can the soil be protected and an adequate production be maintained.

A STABLE RURAL PEOPLE.

To secure a stable and satisfied rural people, it will be necessary for them to have, as has already been pointed out, an income equal to that of the city man in its power to procure the real satisfactions of life. Every attempt to keep

up the country stock and to resist the power of the city to call the best the country produces on any other basis than this, is unsound, and nearly every civilization that has preceded ours has tried the experiment and failed.

But back of all questions relating to the securing of an income, either through greater efficiency as a laborer, or through securing a fairer proportion of what that labor brings, stands the great question of the utilization of this income, or the coining of it into higher standards of family life.

Rural people must be brought to a realization that the country is not merely a place in which to live while accumulating money enough to enable them to live in town. They must be shown that by the wise expenditure of their income on the farm all the real satisfactions of life that the town affords may be procured in the country. The occupation of farming and the life in the country need to be idealized by the rural people.

A people never rise above their ideals. It is what a man thinks of himself and his work that counts for most. Indeed, the effort to live up to a good name, bestowed perchance by some misguided friend, has been the means of making many a good man. Give an occupation a good name and it is a better occupation therefor.

In recent years the laboring man has become greatly interested in the cause of labor. He has learned the advantage to him to the cause of labor of bestowing upon the people of his own class whatever prizes he has to bestow. He is easy to organize, too easy sometimes. But it was only when the laboring man had respect for labor that he was able to cope successfully with his age-old enemy, his employer.

The producer, the man on the soil, has not yet learned this elementary lesson in self-preservation. He is difficult to organize, impossible to lead. He idealizes every occupation except his own. To him the open country holds no romance. To the farm boy, the heroes are all in the city. As a result, the world accepts the farmer at the farmer's estimate of himself.

Thus opportunities for the rural people equal to those of the town people and the power and inclination of the rural people to live up to their opportunities, or to phrase it more tersely, income and idealism are the two elements out of which a stable and satisfactory rural civilization will be built. A society having for its object the promotion of the science of agriculture cannot afford to exalt one of these elements above the other.

THE SOCIETY FOR THE PROMOTION OF AGRICULTURAL SCIENCE.

By W. J. Beal,
Amherst, Mass.

The initiative for starting this society appeared as a part of an editorial in *The Scientific Farmer,* in 1879, edited by Dr. E. L. Sturtevant, thirty-six years ago. Excepting the American Pomological Society, I know of none of an agricultural nature that is anywhere near that age.

Persons were to become members only by invitation, a rule that has been strictly adhered to ever since.

I quote from the editorial referred to: "There are a few men, professors in our agricultural institutions, who should take upon themselves the duties of coöperation in giving direction to scientific thought, and who from their position could take the initiative. Why not have an association of those interested in agriculture, and a periodical discussion of subjects which require uniformity of method and combined effort towards elucidation?—an association which should not seek a popular but a scientific membership; an association which should ignore the commonplace opinions and crudities of the popular society-meeting, and should publish only those papers which could pass the ordeal of a competent and critical committee, as being contributions to knowledge and advancing in agriculture; an association where merit should be appreciated and humbuggery exposed without fear and prejudice. Gentlemen, we await your move."

The writer promptly replied favoring an effort to organize a society like the one with which you are now familiar. This reply may be considered the second step toward the starting of a society. Each of us named a few others who we thought suitable men to help in the organization. Dr. Sturtevant writes, "My idea was an organization of gentlemen interested in agriculture, whose promise should be an

annual discussion of appropriate topics. I would have it so established that its endorsement should carry recognition and value, and so high-toned that to be a fellow would be considered a high honor. The idea is a high one which shall not court popularity, but encourage individual and associate work."

"The scheme embraces:

"1. To secure unity of action.

"2. To encourage precision of observation and method.

"3. To afford appreciation to work that is deserving.

"4. To act thru committees in originating and giving directions to suitable plans.

"5. To influence agricultural education.

"The line should be sharply drawn between good writers and good workers. A dozen men are enough to begin with. The different branches of agriculture should be represented as far as may be."

A circular was sent to the prospective members with the signatures of fifteen persons and this brought favorable replies from others, making twenty-one in all.

The first meeting was held in Boston in the summer of 1880, in connection with a meeting of the American Association for the Advancement of Science. The meeting was well attended by prominent men, many of whom were not members of the Society.

Although the Society is now thirty-five years old, the number has never exceeded 152, and these were selected from the United States and Canada and from all science pertaining to agriculture.

Owing to the distance apart, usually not more than 30 per cent. get together at any one meeting, and only a small number of these attend two consecutive meetings. These facts make it difficult to arrange the programs. The new members have stayed by the society well. Each name appears in a biography in *Who's Who In America*. They are interested in one or more of the following subjects: Chemistry, forestry, animal products, dairying products, soils, meteorology, agricultural physics, crops, fertilizers, veterin-

ary medicine, entomology, remedial measures, botany, grasses, diseases of plants, fungicides, weeds, seeds, horticulture, irrigation, breeding of animals and plants, and a few other items.

Formerly most of the meetings were held in connection with the American Association for the Advancement of Science, but more recently they have all been held in connection with meetings of agricultural colleges and experiment stations. Papers were most numerous in about 1900, while yet there were few societies of a kindred nature. The program consists largely of papers that will interest an audience in a wide range of subjects, arranged in a program spoken of as a *symposium,* at which there are in attendance members of two to five other societies.

The meetings have always been quite informal; the Society continuing many years without any constitution or by-laws. The steady, quiet demeanor of its members have won for them a good name.

The Society lacks two things: an index to all the volumes complete and some money to pay a secretary who shall serve for many years, keeping in mind all the business of the Society.

THE TREND OF MODERN AGRICULTURAL PRACTICE.

By I. P. Roberts.

Mr. Chairman, Old Friends, and Members of the Association:

I am delighted to be with you once more, here in this land of plenty, and at a time when the promise of better things in agriculture is being fulfilled. To those who are strangers to me it is proper to say that for more than half a century in the Middle West and in New York State, I stood on the advance line for a saner, more scientific and more profitable use of our stupendous landed inheritance. But all this is past and I am here by reason of the pressing invitation of your Secretary who, I think, desired to illustrate his training in Geology by exhibiting a specimen of the pre-historic Professor of Agriculture.

For the last twelve years I have been merely an onlooker, and so have had leisure to make a wide comparison of farm practices from the period when the Nineteenth Century was still young down to the present time. As part of the history of the development of agricultural practice, I may relate a single instance:

My grandfather cut down the great beech and maple trees which then covered a considerable portion of Central New York, made them into logging lengths, piled and burned them, gathered and leached the ashes and boiled the lye down to a crude potash. He then loaded it into a skiff and rowed fifty miles to Syracuse where he exchanged it for two hundred pounds of salt.

How many calories did my grandfather use to procure one pound of salt? How many do you use to obtain one pound of a purer chloride of sodium?

In order to illustrate the amount of energy expended formerly in the production of a bushel of wheat, I may describe to you my first harvest field where men and women

were laboriously cutting wheat with hand sickles as they still do in many parts of Europe. Later I see myself, a stripling boy, trying to cut wheat with a grain cradle—essaying to do a man's work. In those days the motive power of the reapers was generally a keg of whiskey, but mine was only hasty beer!

At the present day, I see a great tractor-harvester sweeping down upon me in a blinding cloud of dust, discharging now a pile of straw and now a bundle of filled sacks; and passing on into the distance until the sun sinks into the Pacific. Five hundred or more bushels of wheat harvested in one day, waiting only through the night to start on its journey to the hungry Belgians. And I rejoice to see men and women relieved from much of the exhausting labor of cultivation and of harvesting, even though the modern farmer gets less for his wheat than they did; and even though he gets less than it costs him to raise it.

During these recent years of comparative leisure as an onlooker, I have devoted much time and pains to determining approximately the average cost of producing a bushel of wheat, including its delivery to the nearest market. When it will not discourage the grain farmer too much, I may publish in detail the digested results of my inquiries. But suffice it to give here the net results and the conclusions to be drawn from them.

Taking eleven of the largest wheat-producing states, and three to ten counties in each of them which produce the greatest amount of wheat, I selected the most reliable wheat raisers in those several counties to report in detail upon the cost of producing and marketing wheat. I received 70 replies representing as many grain-raisers, and from these I collated the following results:

In 1911 the average cost of raising a bushel of wheat was $1.03+.

In 1913 the average cost of raising a bushel of wheat was $1.04+.

For the most part the same farmers reported at the two periods.

If this represents accurately—as I believe it does—the average cost of raising wheat in the most favored districts, we must conclude that the average cost of raising wheat throughout the whole United States is somewhat greater—in some localities very much greater. This result was corroborated by Joseph Leiter, the noted wheat operator, in his testimony at the New York State Inquiry last winter, when he said that American farmers had long been selling wheat for less than it cost, and that the farmer had nothing to say concerning the price he should receive for his product. Let us now compare the cost of raising wheat with the price of wheat in the public market, during the last half-century.

The average price of wheat in June, arranged by decades for the fifty years preceding 1912, at Fall Creek Mills, Ithaca, New York, was as follows:

1863–1872	$1.91
1872–1882	$1.33
1882–1892	$1.04
1892–1912	$0.96

The price in June of this year (1915) fluctuated around $1.00. The average price of wheat during forty years preceding 1912, in June at Ithaca, New York, was $1.00; and for October during the same period, $0.973 cents.

In the Twelfth Census I find the following figures as to the value of cereal per acre:

The value of all cereals per acre was $8.02; in the North Atlantic Division in which three-fourths of the cereal crop was produced, the average value per acre was $8.18; in the South Atlantic Division only $6.55; and in the South Central Division, $7.12.

The average annual rental value of wheat lands, I find from my investigations, was in 1911 somewhere between $4.00 and $6.00 per acre. It should be noted in connection with these Census figures that this is about the worst showing that cereals have made in the last forty years.

However, in order to discuss agricultural practice intelligently we should not deceive ourselves with the best

yields of the best district in the best period, but should face the average and the worst unflinchingly. From this only can we draw safe conclusions.

The average yield of wheat throughout the United States is being maintained and possibly slightly increased in three ways: First, by better preparation of the land; second, by more general use of fertilizers; third, by discarding some of the poorer wheat land and substituting for it virgin soil. Most of the soil now devoted to wheat-raising is losing year by year somewhat of its surplus productive power. Ideal conditions of heat, moisture, sunshine, etc., are never present throughout the entire growing season and at some period there comes a severe pinch which tests the plants to the utmost. If there is not a liberal store of available plant food present to help the plants regain their normal vigor, the harvest will be much diminished. When plants are seriously checked in their growth the sap-cells formed are abnormally small, and therefore the plants have a hard struggle to recover their full capacity of fruitfulness. Plants seldom use *all* the available nutrition or even all the *easily-available* plant food. The less there is, the longer the period of recovery from any check; the more there is, the quicker the recovery.

The grain-raiser should learn a lesson from the expert driver of an automobile, who goes merrily along the improved state highway using less than 20 per cent. of his horse-power. When he strikes the dirt road and the foothills he calls on a little more of his horse-power. When he approaches the last rocky divide of the Sierras, for a brief period he calls on all his reserve energy up to 40 or even 60 horse-power; that is, he must use all the power he has been holding in reserve.

Metaphorically, the surplus fertility of the soil represents the last horse-power and without it the grain-raiser will face a constantly diminishing yield per acre.

I beg to remind you that it's "the last March wind that killed the widow's cow." Had she had just a few pounds of reserve energy in the shape of fat she would have lived

until the fields were clothed in green and would have given a good account of herself.

Go back to the ancients and remind yourselves of this great lesson: "Thou shalt not muzzle the ox that treadeth out thy corn," which, translated into Pacific Coast English, means: "It does not pay to rob or cheat thy partner, the beast of burden"—much less to rob the soil which supports both man and beast. Oh, ye Gods, who rule over the waving fields of grain, how long will ye permit ignorance, carelessness and false economy to take more than one-half of the potential crop before the harvest!

Happily, it is not too late to mend our ways, for we have at last received the necessary scientific facts and have proved that these facts can be applied successfully to the betterment of the farmer and the improvement of the land he tills. The trained agricultural scientist is abroad in the land to give aid in directing the forces of nature into more productive channels. If some of you who are here should live out your allotted four-score years you will see most of your acres producing 50 per cent. more than now. But while agricultural practice in wheat culture has changed and greatly improved in the last half-century, the United States is still unable to raise a bushel of wheat for one dollar. Far greater changes will have to be made if the wheat lands are to be handed down in such a condition as to make wheat-raising fairly profitable. The meager average yield of from twelve to fifteen bushels per acre must be doubled, if we would save the grain farmer—for a doubling of the price is not likely to occur.

I give this advice on the basis of what has already occurred in the dairy industry. Formerly from five to ten per cent. of the butter fats produced were fed to the appreciative swine. Now butter fat—if it gets away from the trained dairyman—has to sneak away in the night through the smallest of holes. You are too young to remember that rich and wasteful farm buttermilk, fresh from the churn, which had four to five per cent. of the fats to make it go down slicker than an oyster. Go to the Dairyman, Thou

tired Grain-raiser, and learn economic wisdom! The yield of milk and butter fats in many dairies has been increased, since my own middle-age, by at least 200 per cent. and the limit is not yet reached—see the recent record of the Greatest Cow on Earth!

Dairies are now open all the year around where once they were unproductive for a third of the year. The dairyman now keeps a strict account with his de-horned and tamed working partner. He weighs out her concentrated foods—twenty to forty pounds a day—and keeps account of the results of this food, amounting to fifty, seventy-five or even one hundred pounds of standard milk per day. Only a few dairymen linger behind and are still trying to produce milk from hay and straw and sometimes even from ice-water!

The steady trend of dairy husbandry practice is to conserve the productive power of the land! If any grain-raiser would take an acre of land and treat it as well as many a dairyman treats his cows, the yield would jump from twelve and fifteen bushels per acre to forty and fifty.

My eyes are not yet so dim that I do not see posted everywhere the signs of rapidly-changing and improved practices in the management of many of these farms, located in the fairest portion of the globe. But a very large number of grain-raisers do not yet read these signs intelligently. They do not yet realize that a yield of twelve to fifteen bushels spells ruin—it does not give even a living wage for the farmer himself.

The agricultural practices of the past generation, of grain-raisers especially, tended to deplete the productive power of the land. They have left to the better educated farmer of your day the task of restoring it by rotation of crops; by deeper and better tillage, by manure, both barn and green, by commercial fertilizers and by taking the cow into partnership. The cow-colleges will furnish the cows.

The remedy for unprofitable agriculture is self-evident: Treat your partner, the land, liberally and it will reward you liberally!

THE VITALITY OF SEEDS BURIED IN THE SOIL.

By W. J. Beal.

That the following statements be understood, it will be necessary for me to repeat a little of what has formerly been published in the proceedings of this Society.

In the autumn of 1879, now over thirty-six years ago, I began the following experiments with the view of learning something more in regard to the length of time the seeds of some of our most common plants would remain dormant in the soil and yet germinate when exposed to favorable conditions.

I selected fifty freshly-grown seeds of each of twenty-three different kinds of plants. Twenty such lots were prepared with the view of testing them at different times in the future. Each lot or set of seed was well mixed in moderately moist sand, just as it was taken from three feet below the surface, where the land had never been plowed. The seeds of each lot were well mixed with the sand and placed in a pint bottle, the bottles being filled and left uncorked and placed with the mouth slanting downward so that water could not accumulate about the seeds. These bottles were buried on a sandy knoll in a row running east and west, and placed fifteen paces northwest from the west end of the big stone set up at the Michigan Agricultural College by the class of 1873. A boulder stone barely even with the surface soil was set at each end of the row of bottles, which were buried about twenty inches below the surface of the ground. I should make an exception in the case of the acorns, which were placed in the soil near the bottles and not inside bottles. At the end of five, ten, fifteen, twenty-five, thirty and now thirty-six years, sets of these seeds were tested for vitality.

The seeds were not packed in the sand. They had not been subjected to a frost.

The following is the list of names as they were known when buried: Amaranthus retroflexus L. (a pigweed), Ambrosia artemisiaefolia L. (ragweed), Brassica nigra Koch (black mustard), Bromus secalinus L. (chess), Capsella bursa-pastoris Moench (shepherd's purse), Erechthites hieracifolia Raf. (fire-weed), Euphorbia maculata L. (spotted spurge), Lepidium virginicum L. (pepper-grass), Lychnis githago Lam. (cockle), Maruta cotula DC. (mayweed), Malva rotundifolia L. (mallow), Oenothera biennis L. (evening primrose), Plantago major L. (broad-leaved plantain), Polygonum hydropiper L. (smart weed), Portulacca oleracea L. (purslane), Quercus rubra L. (red oak), Rumex crispus L. (narrow dock), Setaria glauca Beauv. (pigeon grass or yellow fox tail), Stellaria media Smith (chickweed), Thuja occidentalis L. (Arbor vitae), Trifolium repens L. (white clover), Verbascum thapsus L. (mullein). These seeds were all grown in the year they were buried.

As I had removed to Amherst, Dr. E. A. Bessey, my successor, took up another lot of these seeds and entrusted them to his assistant, Prof. Darlington, who reported the results up to July 1, 1915. The acorns buried near the bottles of seeds were all dead at the end of two years.

In all tests of the seeds buried in bottles, the results have been far from satisfactory. I mean by this that I have never felt certain that I had induced all the sound seeds to germinate. I moistened the sand containing the seeds and forthwith a goodly number germinated, and then they came straggling along. I dry the soil and wait a few days, and after moistening, in a few days or a few months more seeds germinate. A nice lot of seeds germinated. Why was I unable to induce them to start, when treated to various degrees of temperature and moisture for several months?

We see this important point: It is to the advantage of the plants not to shoot up all of their seeds at one time, but to retain a good portion alive in the soil to be ready for

stocking the earth in successive years. Again, we must consider that it makes very little difference whether all the seeds live over for a time or only a small portion of those that were produced, as a living seed now and then left is enough to save the stock and produce new crops of seeds.

Names of seeds tested as known in 1879	5th year	10th year	15th year	20th year	25th year	30th year	36th year
Amaranthus retroflexus L.	X	X	X	X	X	X	O
Ambrosia artemisiaefolia L.	O	O	O	O	O	O	O
Brassica nigra Koch	?	X	X	X	X	X	X
Bromus secalinus L.	O	O	O	O	O	O	O
Capsella bursa-pastoris Moench	X	?	X	X	X	X	X
Erechthites hieracifolia Raf.	O	O	O	O	O	O	O
Euphorbia maculata L.	O	O	O	O	O	O	O
Lepidum virginicum L.	X	X	X	X	X	X	X
Lychnis githago Lam.	O	O	O	O	O	O	O
Maruta cotula DC.	X	X	X	O	X	O	?
Malva rotundifolia L.	X	O	O	X	O	O	O
Oenothera biennis L.	X	X	X	X	X	X	O
Plantago major L.	O	O	X	O	O	O	O
Polygonum hydropiper L.	O	X	X	X	X	?	O
Portulaca oleracea L.	O	X	X	X	X	O	O
Quercus rubra L.	O	O	O	O	O	O	O
Rumex cripsus L.	X	?	X	X	X	X	X
Setaria glauca Beauv.	X	X	X	O	X	X	O
Stellaria media Smith	X	X	X	X	X	X	O
Thuja occidentalis L.	O	O	O	O	O	O	O
Trifolium repens L.	O	O	O	O	O	O	O
Verbascum thapsus L.	X	?	X	X	O	O	X

Results of germination test of seeds buried in the soil thirty-six years.

X — Seeds germinated.

O — Seeds did not germinate.

SOME CALIFORNIA FEEDING PROBLEMS.

By F. W. Woll.

Compared with conditions in the States east of the Rockies, the systems of feeding farm animals followed in California are very simple and, as a general rule, include only a small list of different feeds.

For the purpose of making clear the discussions to be given in the following, a few words as to the agricultural features of the State will be in order. There are at least five rather well-defined agricultural sections in the State, viz.:

(1) The large interior valleys running north and south, with surrounding foothills and tributary smaller valleys.

(2) The Coastal regions north and south of the San Francisco Bay, with their small valleys, hills and mountain chains.

(4) The Southern counties, and

(5) The arid region to the southeast, the Imperial Valley, which has been developed into prosperous agricultural communities only within the last couple of decades.

From an animal husbandry standpoint, the large interior valleys are by far the most important section of the State; more beef and dairy cattle, and hogs are raised here than in any other section, although the Imperial Valley is the banner hog-raising county in the State. Besides in the interior irrigated valleys and the regions tributary to our two large cities—San Francisco and Los Angeles—dairying is an important industry in the Coastal range country, especially the upper Coastal region where favorable pasture and general forage conditions exist on account of abundant rainfall (50 inches or more). The foothills and mountainous section to the north and east, on the other hand, are well adapted to cattle, sheep and goat-raising, and these

branches of stock husbandry assume their greatest importance in this region.

Broadly speaking, the feeds available for feeding our farm animals are wild pastures, either mountain or foothill ranges, or bottom lands, alfalfa, clover, vetch, grain hay, sorghum and Indian corn fodder, among the rough feeds, and among the concentrated, the cereal grains, sorghums, mill feeds, cottonseed meal, linseed meal, cocoanut meal, dried beet pulp and molasses.

In the large irrigated valleys alfalfa is by far the most important forage crop. It is fed to all classes of farm animals, but is of special value in feeding dairy cows and fattening steers. As a general rule, it is fed as the sole feed, being either pastured, or fed green or as hay in corrals. Tens of thousands of dairy cows in the State receive no other feed than green alfalfa or alfalfa hay throughout the year and during their entire lifetime, and, like most of the fattening steers on the mountain ranges and foothills, never taste grain or other concentrates.

EXCLUSIVE ALFALFA FEEDING.

To the student of animal nutrition the exclusive feeding of alfalfa is most interesting, in view of the general adoption of this practice in the section referred to and the good results that it appears to give in individual cases. Objections to the practice readily suggest themselves: Like other rough feeds, alfalfa furnishes a relatively low percentage of net energy, whether fed green or as hay, and good dairy cows, therefore, have to consume amounts of feed to obtain sufficient nutriment for maintenance and milk production. The practice is also at variance with the feeding methods followed in other dairy regions, except in some of the Western States.

The lack of variety might be supposed to form another disadvantage, but there does not appear to be any difficulty in this direction, for farm animals are able to maintain a good appetite on alfalfa alone for any length of time. Another possible disadvantage, which may be a serious one

from a physiological standpoint, is the narrow ratio between protein and carbonaceous components in alfalfa. The nutritive ratio of alfalfa is about 1:4. The ratio recommended by the Wolff-Lehmann feeding standards, on the other hand, range from 1:6.7 for cows producing about 11 lbs. milk daily to 1:4.5 for cows producing 27½ lbs. of milk daily, and rations commonly fed to good dairy cows in the Eastern and Central States have nutritive ratios ranging from 1:6 to 1:8.

On the other hand the simplicity of the feeding operations, and above all, the relative cheapness of alfalfa under ordinary conditions in this State, make the exclusive feeding thereof an attractive practice. The feed cost, in feeding alfalfa only, will not be likely to exceed 10 cents per pound of butterfat at ordinary production price of alfalfa, in the case of good dairy cows, or 30 to 40 cents per 100 lbs. milk. There is no outlay for grain or other concentrates; hence the farmer is independent of feed dealers and the fluctuations of the feed market.

The question whether cows on an exclusive alfalfa diet do not receive more protein than is conducive to best results, either as regards their production or general health, or both, is, however, one that should receive serious consideration. While protein substances have a stimulating influence on the milk secretion of cows, as on processes of growth in general, there are reasons to believe that an excessive supply may cause abnormal conditions and will work against an economical production and the continued usefulness of the cows in the dairy. Since the final nitrogenous decomposition products can only be eliminated through the urine, heavy protein feeding throws a large amount of labor on the kidneys and may result in diseased conditions in animals, as well as in man. This has been shown by numerous investigators; among others by Watson and Hunter in their studies of the influence of diet on growth and nutrition,* and is suggested by the well-known experi-

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* Journal of Physiology, v. 34 (1905), p. 112.

ments with pigs and sheep by Sanborn, Henry, Shelton, Ruggar, and others, in which rations abnormally high in protein substances were fed.

While there is but little exact available information on this point with regard to dairy cows, many observing dairy farmers have discontinued exclusive alfalfa feeding to their cows as their experience had led them to believe that best results can not be secured by following this practice; the opinion is also often expressed that digestive disorders and failure to breed will occur more frequently in herds where this system of feeding is followed than where low-protein rations are fed. As a matter of fact, better returns have been obtained from individual herds after a change to the latter system has been made. Definite data bearing on this point are scarce, however, since but very few of our dairy farmers keep records and have an accurate knowledge of the production of theirs cows.

Since the effect of long-continued feeding of alfalfa on farm animals has not been established, either from the practical side or as to its scientific justification, it becomes important to make a comprehensive investigation of this subject, with regard to the physiological effects of this system of feeding on the development of young dairy animals and on the milk secretion. So far a beginning only has been made in this direction by our College; six pure-bred heifers of our own breeding were selected for this experiment, three of which have been fed nothing but alfalfa since April last year, while three have been fed according to the common method of feeding in our dairy herd, alfalfa or green alfalfa being always a part of the rations fed. Each of the heifers in Lot I (alfalfa only) closely resemble one of the animals in Lot II as regards breeding, age, size and conformation. Several dairy-bred grade calves will be included in the experiment in the near future in order that the results obtained may be more representative and lead to accurate deductions with greater certainty.

The heifers are weighed regularly once every month, and careful measurements of the length and heighth of body,

width and heighth of hips, and circumference of barrel, are taken every two or three months. After freshening the production of milk and butter fat by the heifers has been regularly determined as in the case of all other cows in the University dairy herd. Data for three heifers only are available at this time; of these a Jersey heifer, fed alfalfa only, produced 105.06 lbs. of butter fat during the first 20 weeks of her lactation period, while two heifers (also Jerseys) fed mixed rations, produced 137.96 and 180.22 lbs., respectively, during the same period, or an average of 159 lbs.—an increase of about 50 per cent. over the heifer fed alfalfa only. This result is not, of course, in itself of much value, being obtained with three animals only, but it suggests that an exclusive alfalfa diet for young dairy stock at least can very likely be improved upon, either by feeding supplementary feeds of a more carbonaceous character, or by including in the ration a variety of feeds, especially concentrates.

There has been no marked difference to be discerned up to the present time in the thriftiness or the outward appearance of the heifers in the two lots; the gains in the body weight of Lot I, on alfalfa only, have, however, been somewhat higher than those for the heifers in Lot II, viz., on the average, 1.0 lb. per head daily, against 0.91 lb. for two and three heifers, respectively, during periods varying from 242 to 414 days for the different heifers.

SUPPLEMENTING ALFALFA FOR DAIRY COWS.

In addition to studying the direct effect of an exclusive alfalfa diet on the development, health and production of dairy cows, the problem may be attacked from the practical side by adding either concentrates or roughage of other kinds, preferably succulent carbonaceous feeds to the alfalfa, and noting the results. This has been done in two recent series of experiments at the University farm. In one of these rolled barley was fed with green alfalfa and alfalfa hay, and in the other Indian corn silage or milo silage was fed supplementary to alfalfa.

Two experiments were conducted during the summers of 1913 and 1914 in which the rations fed in comparison with alfalfa only were composed of alfalfa and grain (rolled barley), the nutritive ratios of which were, therefore, somewhat wider than that of alfalfa.* In both experiments an immediate increase in the production of milk and butter-fat by the cows was secured, amounting to 13 to 16 per cent., but the increase was not sufficient to pay for the extra cost of the ration at ordinary market prices of feeds and products. The conclusion is drawn from the experiments, however, that on account of the increased production obtained and the residual effects of the grain feeding on the milk secretion as well as its favorable influence on the condition of the cows and their offspring, the practice of feeding grain to cows on alfalfa is economically sound and may be safely recommended. This holds true especially for heifers, young cows, and heavy-producing animals which cannot be brought to a maximum production on roughage only, even if this be as excellent and palatable a feed as green alfalfa or good alfalfa hay.

In many cases alfalfa is supplemented by pumpkins, pie melons or silage in the feeding of dairy cows; the nutritive ratios of the rations thus fed are wider than alfalfa alone, and conform somewhat to that of accepted feeding standards. During the past two winters experiments were conducted at the University farm in which corn silage or milo silage was fed with alfalfa hay to 14 and 19 cows, respectively. In the case of some cows only rough feeds were fed, alfalfa hay and silage, or alfalfa alone, being fed during periods of four weeks' duration, while other cows received, in addition, the usual grain rations for cows in the dairy herd, in the proportion of 1 lb. to every 5 lbs. of milk. The results of the second experiment have not as yet been compiled, but from the study of the data made so far, it appears that both kinds of silage proved effective components of the rations fed and saved more than their equivalent of

* See Bulletin 256 of the California Station.

dry matter in alfalfa hay. The production of milk and butterfat by the cows was also fully maintained on the silage rations, in the first year's experiment even increased to some extent over that of the alfalfa ration.

CALF FEEDING.

As our urban population increases and more milk is used for direct consumption or as cream or ice cream, and as cheese factories and milk condenseries become more numerous, the problem of rearing strong and thrifty calves that will make good future dairy cows becomes one of considerable difficulty. Nearly all calf-feeding experiments that have been conducted by American experiment stations in the past have been planned with a view to determining the best supplementary feeds or feed mixtures with skim milk, and in nine cases out of ten corn meal has been the main component of the grain ration, ground oats, mill feeds and oil meal being generally fed with the corn meal. Such a grain ration evidently is not suited to conditions in this State. Indian corn is grown to only a small extent here, and oats are always high-priced. On the other hand, we have an excellent dairy feed in barley, the main cereal crop of the State, and also have a promising group of feeds in the grain sorghums, milo, kafir, durra, etc. It seemed desirable, therefore, to determine the value of these grains for feeding skim milk calves, and a series of calf-feeding experiments have accordingly been conducted with them at the University farm since November, 1914. Two lots of eight calves each about a month old were fed during a preliminary trial of ten weeks' duration, November, 1914, to January, 1915. The rations of one lot were composed of a grain mixture of two parts each of rolled barley, rolled oats and wheat middlings, and one part of linseed meal, all by weight, the other lot receiving the same ration except that no oil meal was included therein. Alfalfa hay and skim milk were fed both lots in proportion to the size and capacity of each animal. The calves in Lot I, fed oil meal,

gained on the average during 10 weeks 1.14 lbs. per head daily; and Lot II, 1.27 lbs.

The next trials were conducted January to April, 1915, with 24 dairybred calves, separated into three even lots of eight each. Lot I was fed a grain ration of ground barley, ground milo and linseed meal, in the proportion of 3:2.1, by weight, while Lots II and III received ground barley and milo only, fed in the proportion of 3:2. The main difference between the latter two lots lay in the age of the calves included in each, which was 115 days, on the average, at the beginning of the trials for Lot II and 42 days for Lot III.

Skim milk warm from the separator was fed in all cases in two feeds daily, 10 to 20 lbs. per head, according to the age, size and capacity of each calf, and these received in addition all the whole alfalfa hay they would eat. The average rations fed to each lot, and the gains made, were as follows: About 11 lbs. of skim milk, 5.7 lbs. of alfalfa hay, and 2 lbs. grain to Lots I and II, while the calves in Lot III were fed on the average 12 lbs. of skim milk, 2.8 lbs. of alfalfa hay and 0.8 lbs. of grain.

The calves fed grain with oil meal gained 1.84 lbs. per head daily during 12 weeks, while the corresponding lot, receiving barley and milo, gained 1.74 lbs., and Lot III, being younger calves, gained 1.33 lbs. daily, or slightly more than the calves receiving the oil meal mixture in the first experiment.

Weighings were also made of the calves about every four weeks after they were put on pasture on the completion of the experiment proper, in order to ascertain whether the method of feeding followed during the experiments influenced in any way the gains made by the calves on pasturage; during the ten weeks following the close of the experiment the oil-meal lot gained 1.07 lbs. per head daily and the lot receiving barley and milo only gained 1.10 lbs.

In addition to furnishing data as to the value of barley and milo for feeding skim-milk calves, the method of feeding adopted in these trials throws light on the questions of

fundamental importance from a nutritional point of view. Both skim milk and oil meal are high-protein feeds, their nutritive ratios being about 1:1.6. In view of this fact, and with a nutritive ratio of 1:4, or wider, being called for by the feeding standards for growing dairy stock, is it desirable to add oil meal to grain mixtures fed to skim-milk calves, who are, moreover, receiving alfalfa hay as roughage, and is such an excessive protein supply conducive to the best development of the calves as future members of the dairy herd? Trials conducted at the Iowa Station showed that linseed meal fed alone with skim milk did not produce as satisfactory results as oatmeal or corn meal, but it has not been proved that the addition of this feed to grain rations for skim-milk calves is advantageous from either a physiological or practical point of view. The results obtained in the feeding trials at the University farm suggest that the addition of oil meal to the grain ration for young calves fed skim milk and alfalfa hay is of no particular advantage, so far as gains in body weight, thriftiness, or general appearance of the calves are concerned, either during the period of actual grain feeding and for some time subsequent to the same, and it is a disadvantage in so far as it increases somewhat the expense of the grain ration.

It is nevertheless a question whether one would be justified in discouraging the use of this feed in rearing dairy calves under conditions similar to those under which these trials were conducted. Oil meal improves the palatability of most grain mixtures, and especially one of barley and milo, and insures that the animals take their feed with a relish at every meal. Linseed meal has also a special dietetic value and when its price is not prohibitive may be included in the ration for dairy calves under the conditions prevailing in this State, even though the nutritive ratio of the rations thus fed becomes much narrower than any recommended by authorities on animal nutrition in this country or abroad.

Here again, as in the case of exclusive feeding of alfalfa, we cannot look upon the question as definitely settled, for

investigational work of quite another type, involving studies of intricate physiological processes, must be made before the bearing of this system of feeding will be fully understood, but the deductions stated appear justified in view of our present knowledge of the subject.

The value of *grain sorghum* for feeding dairy calves under similar conditions as in our trials, which closely resemble those on the better class of dairy ranches in the State, is clearly shown by the results given. It seems evident that when feed is mixed with rolled barley at least, or rolled barley and oil meal, there is no appreciable difference in the nutritive effect of the milo and Indian corn, and this grain sorghum may be substituted for the latter in grain mixtures for calves raised on skim milk with very satisfactory results, both as regards the gains made by the calves and their general health and thriftiness.

THE SILO IN CALIFORNIA AGRICULTURE.

During the last quarter of a century or more the *silo* has become a common feature of the equipment of the dairy and stock farms, and the methods of feeding dairy cows, beef cattle and sheep have been largely revolutionized by the general introduction of silos in the States where dairying and stock-raising are important industries. Silos have also been erected in considerable numbers in this State during late years, and there is perhaps no county in the State at the present time where the sight of the characteristic tall, round wooden or concrete structure does not greet the eye.

The silo was first adopted by the dairy farmers of the Eastern and Central States, and it has found the widest distribution in dairy sections. It is, however, rapidly becoming of equal importance to the stock farmer in general. It furnishes a palatable succulent feed of uniform quality for feeding during the winter months and any other period when green feed is scarce or lacking. Where green feed or pasturage is available nearly the year around, as in the dairy sections in this State, there is less occasion for provid-

ing silage than where the winters are long and late summer droughts make it difficult to provide sufficient feed for the maintenance of a large production. While the silo is, therefore, not likely to become so important to California farmers as to those in the Eastern States, there are few sections that will not be greatly benefited by a general distribution of silos within their borders.

The crops that are apt to become most important silage crops to California farmers are: alfalfa, sorghums and Indian corn. The first cutting of alfalfa is siloed for the reason that weeds, especially foxtail (*Hordeum murinum*) which generally makes up a large proportion of the crop, may be made into a valuable succulent feed by the siloing process, while they render the crop worthless if cured into hay, owing to the stiff beards of the foxtail and the presence of various other coarse weeds that are unpalatable to stock in a dry condition. In many cases the first crop of alfalfa is so weedy that farmers do not attempt to cure it into hay, but it is raked into windrows and burned. If cut at a somewhat early stage of growth, before the foxtail has reached maturity, such weedy alfalfa will, however, make a satisfactory silage that will be eaten practically without waste by fattening steers, dairy cattle and sheep. The admixture of non-leguminous plants in alfalfa seems to be an advantage rather than a detriment, so far as the quality of the silage is concerned. In an experiment with fattening steers conducted at the University farm last summer about 100 three- and four-year-old steers were fed for 46 days an average ration of about 10 lbs. hay, 20 lbs. silage from first-crop alfalfa, and 8½ lbs. rolled barley, making an average gain of 1½ lbs. per head daily on this feed. Toward 60 tons of alfalfa silage was consumed on the experiment. This alfala cured into hay would have been of no value, as it contained over 55 per cent. of foxtail and other noxious weeds and the cutting was, moreover, delayed until the foxtail was nearly ripe.* As the last cut-

* Circular 134 of the California Station, "Alfalfa Silage for Fattening Steers."

ting of alfalfa generally comes after the rainy season has commenced, it is often difficult to cure this into hay. Advantage may, therefore, be taken of the siloing system for preserving also this crop for feeding purposes.

The California dairy farmer will never depend on the Indian corn plant for feeding his stock to a similar extent as it is the case in the Central States. Corn can be successfully grown in many sections of the State, however, especially in our large valleys, and its culture is increasing in a marked manner every year among leading dairy farmers. It appears important to them to secure a carbonaceous feed to supplement alfalfa in feeding farm stock and it is always siloed under such conditions. Where Indian corn does not do well or where a farmer does not care to grow corn for some reason or other, the sorghum varieties will prove excellent substitute silage crops. At the University farm three such crops were siloed last year: dwarf milo, feterita and a saccharine sorghum, early amber. These were fed out in experiments to cattle and sheep during the past winter and proved valuable succulent feeds, being palatable to stock, of a pleasant aromatic odor, and of a somewhat lower acidity content than Indian corn. While not fed under conditions that allowed of strict comparisons of feeding values, our own trials and these conducted elsewhere indicate that the silage from any one of these crops may be considered of only slightly lower feeding value than Indian corn silage, at least for feeding dairy cows.

Other silage crops that will doubtless prove valuable to California farmers with the more general future distribution of silos are: oats, barley or wheat forage, and vetches grown and siloed with one or the other of the cereals. It would seem that oats or volunteer grain cut in the early milk stage will be likely to become most important silage crops; they can be siloed early in the season and the silage fed out during late summer when green feed is likely to be scarce. The silo can then be filled again in September or October with Indian corn or sorghum grown on the land

from which the grain was cut, and both the land and the silo thus made to do double service at a minimum cost.

In the northern Coastal region of the State, which is one of our most important dairy sections, neither Indian corn nor alfalfa can, as a rule, be successfully grown. Clover, vetches and root crops do well in this humid section, however, and rye grass and clover, and vetches with oats or either of the other cereals make excellent silage crops.

In the central and southern coast region and in other sections of the State with similar climate and topography, there is special need of providing green or succulent feed during the latter part of the summer when no more feed is to be had on the hills and slopes. Cows, as a result, generally dry up in this region about the time the hillsides assume their brown coloring, and are, therefore, unproductive for a much longer period than is consistent with profitable modern dairying. The silo will in time be likely to become of greater importance here than almost anywhere in the State, and its adoption will mean greater and more uniform income from the dairy herds than is now generally secured.

YELLOW-BERRY IN WHEAT: ITS CAUSE AS INDICATED BY ITS COMPOSITION.

By Wm. P. Headden.

We have from time to time had different causes assigned for the varying quality of wheat kernels, their flintiness or starchiness. No consideration is given at the present time to the bread-making quality of the flour that they may produce. It is stated by some that there is a relation between the nitrogen supply of the soil and the nitrogen content of the grain. This is questioned by others. Le Clerc, in Year Book for 1906, says: "Dry-land wheat contains 0.73 per cent. more nitrogen than irrigated wheat, weighs less per 1,000 grains and the percentage of flinty kernels is markedly greater. It is almost always the case that irrigation tends to produce a mealy grain, although in several instances it has been noted that even under irrigation the grain has kept its flinty character. This is explainable only on the theory that the irrigation has not been excessive. * * *"

Prof. Thatcher says, "It appears from the analytical figures already obtained in this study and from similar results obtained by other investigators, that the chief, if not sole, factor in determining the comparative chemical composition of wheat of the same variety grown in different localities is the climatic conditions during the harvest and that differences in the composition of the soil have very little, if any, effect upon the quality of the grain except insofar as the soil affects the moisture supply of the plant." (Wash. Bul. 91, p. 27.) "Formerly it was thought that the composition of the soil had a great deal to do with the composition of the crop grown upon it." (Wash. Bul. 100, p. 40.) Prof. Thatcher thinks that this thesis has not been maintained by the results of experiments, and adopts the conclusions of Le Clerc in Bul. 128 of the Bureau of Chemistry, U. S. Department of Agriculture, which reads: "Wheat of the same variety obtained from different sources

and possessing widely different chemical and physical characteristics, when grown side by side in one locality, yields crops which are almost the same in appearance and in composition." * * * "These differences are for the most part due to climatic conditions prevailing at the time of growth. The results so far obtained would seem to indicate that the soil and seed play a relatively small part in influencing the composition of crops."

These statements evidently pertain to the crop produced without further distinction between kernels of varying physical properties. Le Clerc takes cognizance of the distinction between flinty and starchy kernels and attributes mealiness or starchiness, in some instances at least, to irrigation. It would seem to be a just inference that these authors include mealiness as one of the effects of climatic conditions. They are not alone in holding this view. They are fortunately definite in their statements that the climatic conditions have more to do with the composition of the grain than the soil.

Without any attempt to account for the fact, Snyder states, "the light-colored kernels differ from the dark-colored kernels in composition." He says, in writing of color as an indication of composition, "The dark kernels average 2.65 per cent. more protein than the light-colored ones." "Soft winter wheat from Oregon contained less protein than any hard wheat, but soft wheat from Maine contained as much protein as the hard wheats."

Again he says, "The difference between the percentage of protein in light- and dark-colored seeds from the same sample is from 1 to 3 per cent. This statement pertains to dark and light kernels grown from the same lot of seed."

Again, "Some wheats are so uniform in color that no selection, based on difference of color, can be made. In other lots, both of soft and hard wheats, the color varies so that three grades can be made. In such cases the lightest-colored seeds are the poorest in protein." (Minnesota Bul. 85.)

In Minn. Bul. 102, "Soil Investigations, Effects of Fer-

tilizers on the Composition of Wheat," under the caption of Quality of the Wheat, Prof. Snyder says, "The factors influencing this are the fertility of the soil, the character of the seed and climatic conditions. The effects of fertilizers upon the quality of the wheat were studied in connection with these fertilizer experiments. The samples compared were grown from the same seed and in the same locality, so the influence of the seed and climatic conditions were eliminated."

We may state his conclusions as follows: "In many instances the fertilizers exerted some special influence upon the growth of the crop; nitrogen alone retarded maturity and minerals alone hastened maturity. In some cases the size and character of the kernels were influenced by fertilizers. The fact that the physical characteristics of the grains are influenced by the amount and kind of plant food is indicated in a number of the trials. In general the heaviest weight and best quality of wheat was produced on the fertilized plots. Nitrogen alone did not exert as great an influence toward improvement of the kernels as the minerals alone. In a few instances, however, nitrogen alone improved the glutinous character and general appearance of the grain. * * * Increasing the amount of nitrogen in the soil increases the amount of nitrogen in the grain. * * * This increase in nitrogen alone may result in a poorer quality of grain, for, while nitrogen alone increases the crude protein content of the grain, it is necessary, in order to secure at the same time an improvement in the quality, that the nitrogen should be associated with the other elements of plant food. The results indicate that it is possible to increase the protein content of wheat one per cent. or more through the use of fertilizers and also to secure an improvement in the quality." Dr. Hall, of Rothamsted, is quoted to the effect that an increase of nitrogen in the grain is not necessarily followed by an improvement in the quality, "strength," of the flour made from it. Still Prof. Snyder's conclusion is that "The yield of wheat and its bread-making qualities can be enhanced by increasing the

fertility of the soil and that there is a very close relationship between the amount of available plant food in the soil and the quality of the wheat produced and its bread-making value."

The views here stated suffice to indicate that there is a decided divergence of opinion regarding the relative importance of the factors considered as influencing the composition and quality of wheat. Those investigators who have endeavored to maintain uniformity of soil under varied climatic conditions conclude that the soil conditions are of minor importance. Le Clerc says: "The results so far obtained would seem to indicate that the soil and seed play a relatively small part in influencing the composition of the crops." This statement is cautiously framed and pertains only to the composition of the wheat. Prof. Thatcher adopts this conclusion and also makes the statement, "It appears from the analytical figures already obtained in this study, and from similar results obtained by other investigators, that the chief, if not the sole, factor in determining the comparative chemical composition of wheat of the same variety grown in different localities is the climatic conditions during the harvest, and the differences in the composition of the soil have very little, if any, effect upon the quality of the grain, except in so far as the soil affects the moisture supply of the plant."

Shaw and Walters (Calif. Bul. 216, p. 566) say: "It would appear from the results that a normal soil has little, if any, influence upon the nitrogen content of the wheat kernel, but that the climatic factors are the controlling ones."

On the other hand, those who have experimented under the same conditions of climate, but varied the soil conditions by the application of fertilizers, hold that the composition of the grain may be profoundly affected by the soil conditions, but recognize the influence of seasonal differences. Snyder says of his experiments: "That the results indicate that it is possible to increase the protein content of wheat one per cent. or more through the use of fertilizers and also to secure an improvement in quality. "That an

increase in the protein content can be obtained by the use of fertilizers is shown by the Rothamsted experiments, but the quality was not maintained. The experiments carried out at the Ohio Experiment Station are interpreted as showing that the soil conditions are less effective in influencing the composition of wheat than the seasonal, *i. e.*, weather, conditions, but that the soil conditions are not without great influence.

It is evident that in the statement of the results of experiments there is often no distinction made between composition and quality of grain. Also, there is often a failure to consider the soil conditions at the beginning of the experiments so that we are compelled to accept the statements of results as they are made, assuming that the experiments are, in all respects, comparable. These are conditions very difficult to realize and probably seldom obtain. This is by no means always chargeable to inconsiderateness on the part of the experimenter but is, sometimes at least, to be attributed to our inability to recognize the conditions. These are considerations for which we should make allowance. The recorded observations on the effects of fertilizers are at variance, but this is to be expected rather than otherwise, for some of them may have been made under conditions of soil fertility in which fertilizers might produce either insignificant results or greatly exaggerated ones according to the lack or abundance of these elements at the time of the experiments, or the results might be due to the altered ratio in which the elements were present before and after the application of the fertilizers.

I disclaim any idea of bringing these views into harmony, but in the pursuit of another object I have obtained data which may throw some light upon the subject, especially in regard to that phase of the question which regards the composition of the wheat. I wish to state emphatically that at the present time I have nothing to present regarding the quality of the flour produced. All that I shall say pertains only to the physical properties and chemical composition of the grain.

The physical properties of the kernels are evidently one of the features to which others have addressed themselves. I have already quoted from Le Clerc that "It is almost always the case that irrigation tends to produce a mealy grain, although in several instances it has been noted that even under irrigation the grain has kept its flinty character. This is explainable only on the theory that the irrigation has not been excessive." While this statement is extremely guarded, there can be no question but that the author holds that the flinty or mealy character of the kernels is determined by irrigation. Snyder considers the color of the kernels an indication of their composition, but does not, so far as I recall, distinguish them as flinty and mealy; he does, however, say that in some samples the color varies so that three grades can be made. Other writers—Kosutany for instance—classify the kernels as flinty, half-mealy and mealy, and so does Schindler. This condition is known by the ranchmen of the Dakotas, Nebraska, Kansas, Colorado and possibly of other States, as yellow-belly or *yellow-berry*. This condition has been attributed to various causes: climatic conditions, fungi, ill-advised handling of the grain, to irrigation, a heritable tendency, and to the lack of fertility of the soil. I have presented this phase of the subject in Colo. Bul. 205, "Yellow-berry in Wheat." After making allowance for differences in the use of terms, there can, I think, be no doubt but that the same condition is designated by the various terms used. The light-colored berries of Prof. Snyder, the white, starchy wheats of the Pacific Coast, the mealy and half-mealy kernels of Dr. Kosutany and the yellow-berry of Nebraska and Kansas, relate to the same condition. Some may doubt whether the white starchy wheats of the Pacific Coast should be placed in this class. While I am not at the present time prepared to insist upon their belonging to it, I am strongly inclined to think that they are all yellow-berry wheats. I have a series of experiments this season whose object is to determine this point.

The view presented in our Bul. 205 is not in accord with

the quotation from Le Clerc, to the effect that this condition is produced by irrigation which he states tends to produce mealiness. Le Clerc approvingly cites Lawes and Gilbert, maintaining, as I interpret it, the same view, but the quotation suggests the manner of action. They (Lawes and Gilbert) say: "The six seasons of bad crops showed rain to have fallen during each of 199 days. The seasons of good crops had but 136 days during which it rained. The probable reason for such differences is that an excessive rainfall dilutes the nitrates in the soil too much and there being but small amounts of carbohydrates in the process of formation, owing to lack of sunshine, less protein is formed, the result is a mealy grain of low protein content." The salient point in this quotation is that mealiness is caused by excess of water which dilutes the nitrates in the soil and to a lack of sunshine which diminishes the rate of formation of the carbohydrates, which in turn affects the amount of protein formed. The conclusion of Bul. 205 is that the cause of starchiness in the yellow-berry kernels is not an excess of water nor a lack of sunshine, but is due to a high ratio of potassium to the nitric nitrogen in the soil. We do not wish at this time to go into the details of this phase of the question, for we hold that they are sufficiently set forth in the bulletin mentioned. I will, however, state that some of our dry-land wheat is very badly affected by yellow-berry, which fact alone goes far toward refuting the claim that irrigation produces mealiness in wheat. I cannot, unfortunately, give the amount of water available to the crops here referred to, but our annual rainfall is less than 15 inches, which amount did not fall on the crop, as its growing season was only about nine months long, nor was there any lack of sunshine. The rainfall at Fort Collins during the months of April, May and June and the first half of July was 8.37 inches for the season of 1914, which is the one here considered. The yellow-berry was certainly not produced in this case by an excess of water, either during the growth of the plants or the ripening of the wheat. If this statement of the case seems inconclusive to some, we

can strengthen it by the results of direct experiment in which we applied 12 inches of water in June and had 9.94 inches of rainfall, 22 inches of water against 8.37 inches, from the beginning of April till harvest, and we grew flinty wheat. Whereas, under the same conditions of rainfall, sunshine and water supply, we also grew yellow-berry wheat. We may further state that we have samples of wheat grown with the application of one, two and three feet of water.* The maximum amount was applied in seven applications, distributing the water through the period of growth and ripening—*i. e.*, from the time the plants began to stool till within ten days of harvesting. There is no difference in the extent to which these wheats are affected by yellow-berry, as the kernels are practically all affected to a greater or less extent. No distinction is made between winter and spring wheats. My own experiments have been made with spring wheats but many of the general samples obtained throughout the State are of winter wheats. Roberts and Freeman (Kansas Bul. 156) claim that the time of planting of winter wheat has an influence upon the yellow-berry. I do not think that they are correct, for it is in our power to determine whether this characteristic shall or shall not appear in our wheat. This fact alone removes the factors which we include under the term "climatic conditions," so far as the production of starchy or yellow-berry kernels are concerned, for we cannot control the climatic conditions.

I wish particularly to consider the differences in the composition of flinty and starchy grains when grown on the same plot of ground and from the same lot of seed, and afterward to show that these differences are of the same character as those which exist between the same wheats—*i. e.*, wheat grown on contiguous plots of the same land and from the same lot of seed, the dark or flinty ones having been grown with the application of nitrates and the light-colored,

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* I am indebted to Mr. Don H. Bark, now with the Canadian Pacific Railway, for the samples of wheat, together with full, detailed cultural notes.

starchy wheats with the application of potassium. It would evidently be improper for me to go into all the details of sixty analyses at this time, besides, it will suffice for all of our purposes if we follow the conventional paths and consider the total protein (N X 5.7) the true gluten (gluten—N X 5.7) and the phosphorus. I will again call attention to the fact that we do not consider the quality of the flour made from these wheats in this paper, only the composition of the wheat. The quality is a distinct subject for subsequent consideration, and for our present purposes I know nothing about the quality of flour. I make this statement, because, as I have mentioned the true gluten, someone might think that I am involving the question of the bread-making quality of these wheats, which many hold to be closely associated with the amount of gluten present. The results of thirty analyses made of flinty and starchy kernels selected from the same sample of wheat show a difference of approximately two per cent. of crude protein in favor of the flinty berries and the same difference in the amount of true gluten, also in favor of the flinty berries. It is almost self-evident that if the protein content of the yellow-berry is lower, that of the starch will be higher than in the flinty berries. We, nevertheless, determined the starch according to the official method, inverting in the autoclave, and find this inference to be true. This difference in the starch is by no means uniform, but varies from less than one to four per cent. While the amid nitrogen is small in quantity, the differences when they appear are in favor of the flinty kernels. The albumin, gliadin and glutenin nitrogen are uniformly higher in the flinty berries. These differences are small when distributed among these different forms, but the tendency seems to be toward a higher glutenin content in the flinty berries. There is also a decided difference in the properties of the wet gluten. This difference is in favor of the starchy kernels,—the gluten from these has, if I may so express myself, more character, does not run down on drying as that from the flinty kernels, nor does it darken to such an extent. Assuming that this darkening is due to

the oxydase present and that the intensity of the color produced is roughly proportional to the quantity of oxydase, we would judge the flinty wheat to be richer in it than the starchy wheat.

In regard to the ash constituents, we find but two differences so large as to justify us in accepting them as positive differences. These are in the amounts of potassium and phosphorus in the wheat, which in the case of potassium is approximately 0.04 per cent. of the air-dried wheat in favor of the yellow-berry wheat. The sulfur in the flinty berries is slightly higher than in the starchy ones. The percentages involved in these cases are so small that we hesitate to insist upon an interpretation, even though we are fully convinced that very minute quantities, expressed in percentages, have great significance in connection with the composition of wheat. I believe that quantities which fall far inside of the errors of our most perfect work and methods are significant in this connection.

The crushing strength of the kernels has been suggested as a means of classifying wheats. This test, applied to flinty and starchy berries, indicates a difference of from 2,000 to 5,000 grams in favor of the flinty berries.

I have stated that we can produce dark-colored, flinty berries by the judicious application of nitric nitrogen—*i. e.*, nitrogen in the form of sodic nitrates—and that, on the other hand, we can increase, if not produce, starchy berries by the application of potassium. The form used was the muriate, but I am now making a series of experiments in which I am using the sulfate in order to eliminate the question of the influence of the acid radical.

The question presenting itself is whether the differences of composition between these flinty and starchy berries are of the same character as those found between the flinty and starchy berries grown on the same plot of ground without the application of either nitrogen or potassium. We find this to be the case in every instance and we include in this statement the comparison of eighteen analyses of samples grown with the application of sodic nitrate with eighteen

analyses of samples grown with the application of potassium. Restated, we find that the nitrate causes the kernels to be flinty, increases the crude protein by from one to three per cent.; also the true gluten by a like amount. The same relation exists between the starch present in the berries grown with nitrates and those grown with potassium as between flinty and starchy kernels grown on the same plot without the addition of these elements. In regard to the ash constituents we find that here, too, the potassium is higher in the wheat grown with the application of potassium than in that grown with the application of nitrogen. The differences range from 0.02 to 0.04 per cent. with almost no exceptions and without regard to variety. These statements hold in spite of some very abnormal samples due to unfortunate weather conditions and a severe attack of rust.

There are further differences in the mineral content of wheats grown with the application of nitrogen and grown with the application of potassium which did not appear in the complete ash analyses which we made of the flinty and yellow-berries grown upon the same plot of ground. In the latter case we found no difference in the amount of total phosphorus present, which finding is without much force as we have but a single pair of analyses, but we find in the case of the other samples—*i. e., eighteen pairs*—that the nitrogen uniformly suppresses the phosphorus, but it cannot be said that the application of potassium increases it, for the check samples are as rich or richer in phosphorus than those grown with potassium. This suppression of phosphorus is exhibited not only in our samples grown with the application of the respective elements, but also, and to even a greater extent, by samples of flinty and yellow-berry wheats grown in the same section of country. The difference in this instance amounts to 0.114 per cent., almost exactly thirty-three per cent. of the phosphorus present in the yellow-berry wheat, or stating it contrariwise, the yellow-berry wheat contained approximately fifty per cent. more phosphorus than the flinty.

There are two points which undoubtedly suggest them-

selves as demanding consideration in this connection. The first one pertains to the effects of irrigation and the second one to the form of nitrogen supplied to the plant, for I have constantly and with purpose specified nitric nitrogen.

In regard to the former point, I have questioned the correctness of the assertion that irrigation tends to produce starchiness, yellow-berry, in wheat. I have also given the differences in the composition of flinty and yellow-berry wheats.

I have nowhere seen any experimental data in substantiation of the assertion that starchiness is produced by irrigation. The assertion is made that dry-land wheat is more flinty than that grown on irrigated land. I take it that this is the consensus of opinion on the subject, based on general observation. Such consensus of opinion is often an excellent expression of the facts, but if it is the basis for the opinion expressed in this case, I think that it is one of the many instances in which it is wrong.

I wish to present the results obtained in field practice on dry-land and also those obtained in two series of experiments with wheat in which the irrigating water applied varied from one to three feet.

The dry-land wheat was a winter wheat and badly affected by yellow-berry. A comparison of the composition of this wheat with that of a flinty sample of the same variety also grown as dry-land wheat during the same season shows those differences which I have mentioned as characterizing flinty and yellow-berry wheats grown with irrigation and the application of nitric nitrogen and potassium. These facts show that the differences are in no way to be explained by a too moderate supply of water and still more emphatically that it is not a question of irrigation. But we will consider the effects of irrigation up to the application of three acre-feet of water. These experiments were made with a spring wheat, Marquis. The wheat was planted April 2; practically all up April 25. It received its first irrigation May 11; its last irrigation, August 15; was ripe, August 25; harvested, August 28; and threshed, September

11. The plots receiving three acre-feet of water were irrigated at intervals of from eight to twelve days. The plots to which two acre-feet were applied received five irrigations and those to which one acre-foot was applied received three irrigations; the last one in each case on August 15. The wheats were all badly affected by yellow-berry. The plots that received the largest amount of water produced rather better-looking wheat than the others, but on examining the kernels by transmitted light it is impossible to make any distinction between them. These samples were submitted to analysis, including the mineral matter, to see if we could find any differences in composition. The analytical results indicate no such differences as we find between the flinty and yellow-berry wheats. The sample grown with one acre-foot of water contained 10.423 per cent. crude protein, 7.669 per cent. true gluten, and 0.450 per cent. phosphorus; that grown with two acre-feet contained 10.557 per cent. crude protein, 7.381 per cent. true gluten, and 0.449 per cent. phosphorus; while that which had received three acre-feet contained 10.519 per cent. crude protein, 8.079 per cent. true gluten, and 0.454 per cent. of phosphorus. These results agree with the physical properties in showing that the amount of water supplied up to three acre-feet produced no differences in composition. It is, however, evident that these data do not disprove the contention, if it should be made, that the application of one acre-foot of water may suffice to produce a maximum amount of change in the composition of the wheat grown in that particular soil. I can scarcely think that anyone would make such a suggestion seriously. If they should, I unfortunately have no sample of this variety of wheat grown with less than one acre-foot of irrigating water, but I have samples of this wheat grown with the application of one acre-foot of water on other soil, and it will not be amiss, perhaps, if I give the character and composition of this wheat: Yellow-berry below 15.0 per cent., crude protein 15.998 per cent., true gluten 11.042 per cent., phosphorus 0.374 per cent. The weather conditions under which all of these samples were

grown were favorable. These data seem to me to prove conclusively that a constant, excessive supply of water does not produce starchiness in the grain.

The other point that I suggested, as proper for me to explain, is why I have used the term nitric nitrogen with such persistency that it suggests a distinction between this and other forms of nitrogen which may be present in the soil. I have not indulged in any reference to the general problems of nutrition; on the contrary, I have confined myself strictly to the cause of and the differences between flinty and yellow-berry wheats, in which connection I have persisted, as I just pointed out, in the use of the term nitric nitrogen. I have done this because up to the present time I have found no reason to believe that even a well-rotted mixture of horse and cow manure applied in liberal quantities will furnish nitrates rapidly enough to prevent the formation of yellow-berry, nor will a liberal application of such manure affect the composition of the wheat produced, though it may very materially increase the yield of both wheat and straw.

I have already pointed out the effects of nitric nitrogen, which I have stated to be an increase of the nitrogen content of the wheat accompanied by a suppression of the phosphorus. These are the principal but not the only effects produced upon the composition of the grain. Its physical effects are the production of smaller-sized, flinty, often markedly-shrunken kernels, which are higher in specific gravity than the wheat produced upon the same land without its application.

I have the data, yielded by three experiments, to present in support of the statement that well-rotted manure does not produce the results shown to follow the application of sodic nitrate. The size of the plots was one-tenth acre; the manure applied was approximately 16 loads to the acre, and the water applied was one, two and three acre-feet. The results were a very considerable increase in the yield, both of straw and wheat, due to the manure. The character of the grain was, however, not affected. Yellow-berry

was just as prevalent as in the grain produced on plots which received no manure.

The composition of the grain is shown by the following analytical results. Crude protein in three samples grown without manure: 10.423, 10.557, and 10.519; in three samples grown with manure, 16 loads to the acre: 10.813, 10.519, and 11.931 per cent. True gluten in the grain without manure, 7.669, 7.381, and 8.079; with manure, 7.864, 8.005, and 7.904 per cent. Phosphorus in the grain grown without manure, 0.450, 0.449, and 0.454; with manure, 0.452, 0.456, and 0.458 per cent. We find in these two parallel series of experiments a uniformity of physical properties and of chemical composition unaffected by either the quantity of water or manure applied, whereas we find that the application of forty pounds of nitrogen per acre in the form of sodic nitrate suffices to produce most radical changes in both the physical properties and chemical composition of the wheat. On the other hand, we find an antagonistic set of effects produced by the application of potassium in sufficient quantities, from one hundred to two hundred pounds per acre. It is for such reasons that I stated in Bul. 205 that the determinative factor in the production of yellow-berry in wheat is the ratio between the nitric nitrogen—*i.* e., available nitrogen—and available potassium.

Someone may ask why our wheats are so mixed, flinty and starchy berries being produced on the same plot of ground. While this question is germain, it lies beyond the task that I set myself in this paper. The explanation, however, is in no way difficult, though its proof involves much labor.

In our bulletin, Colorado Bul. 205, I treated of "Yellow-berry in Wheat," from certain standpoints and concluded that the cause of this affection is a predominance of available potassium and that it can be easily corrected. In this paper I have considered the same subject from an entirely different standpoint and have shown that the differences in the chemical composition of the flinty and yellow-berry wheats are of the most radical character and that we can

bring about these differences at our own pleasure by the addition of nitric nitrogen or of potassium to increase the ratio of the one or the other.

It follows, of course, from what I have just said that I believe that the principal factor in determining the flintiness or starchiness of wheat is not those factors which we understand by climatic conditions, but is the ratio between the nitric nitrogen and potassium in the soil, while phosphorus plays but a subordinate part. It is probable, however, judging from results so far obtained, that in case the entire nitrogen and potassium were present in such proportions as to produce a neutral kernel with no more than a sufficiency of phosphorus to meet the requirements of the crop, a further addition of phosphorus would strengthen the action of the potassium in producing yellow-berry kernels.

SOME RECENT APPLICATIONS OF BIOCHEMISTRY IN AGRICULTURAL SCIENCE.

By R. W. Thatcher.

I had two purposes in mind in seeking an opportunity to discuss this subject before the Society for the Promotion of Agricultural Science. First, I desire to call the attention of the members of the Society to the confusion which exists with reference to the field of work of an "agricultural chemist" and to suggest certain definitions or principles which may be of service in organizing the work of the departments of chemistry in our experiment stations and agricultural colleges. Second, I hope to present certain examples of recent progress in the field which I have come to regard as one of the most promising of those which are open to the agricultural chemist. These examples will be drawn partly from results obtained in our own department, at Minnesota, which are now being prepared for publication, and partly from the published results of other workers in the field; my thought being to present them here not as an original contribution to knowledge of the facts of agricultural science, but as illustrations of the possibilities in this field.

My attention was first called to the need of a discussion of the field of work of the experiment station chemist by a study of the replies to a questionnaire on this subject which had been sent by a station chemist to the Director of each station in this country. These replies showed that a great variety of opinion exists, among the Station Directors at least, as to what service the department of chemistry in an experiment station may render to agricultural science. The conceptions varied all the way from the one that the chemical laboratory should exist only for the purpose of analyzing samples submitted to it by other persons or departments, to that which considered chemical research as being funda-

mental to the development of practically every phase of agriculture. There was also a great variety of opinion as to whether there should be a single, well-organized and thoroughly-equipped chemical laboratory in which all of the chemical work of the station should be done, or several specially-equipped laboratories attached to the departments in which the chemical composition of the materials under investigation is a factor in their research projects.

This variety of opinions seemed to be due almost wholly to the personal training and experience of the men who expressed them and not to any careful study of the opportunities or possibilities for efficient service which the chemist may render to agricultural science. It is my desire to present a few suggestions which may perhaps help to clarify the situation and to remedy some of the administrative difficulties into which the station chemists have been drawn by the rapid development of research and instruction in agriculture.

Historically, the early students of agricultural science were nearly all chemists. The problems in this field dealt largely with the raising of crops, and this, in the older agricultural countries of Europe, was largely a question of the best utilization of plant food from the soil. In England, for example, it is still the custom to speak of the men who are called "agronomists" in this country, as "agriculutral chemists." But with the rapid development of the field of crop production, specialists became necessary and men came to be known as "soil chemists," "plant chemists," "soil physicists," "soil bacteriologists," "plant breeders," "crop technologists," etc., and there have come to be recognized fields of work known as "agrotechny," "animal nutrition," "soils," etc., etc., in what was formerly the domain of the agricultural chemist. What, then, now constitutes the field, or what is the nature of the problems, to which the man trained as a chemist may devote himself in order to best serve the cause of agricultural science?

As a result of a somewhat careful review of the situation, I have come to the belief that four general lines of work

embody most of the problems in which chemical training can be most efficiently utilized. These I have designated as (a) biochemical research, (b) agrotechnical control, (c) sanitary and regulatory work, and (d) analytical service. This I believe to be the order of their relative importance under our particular conditions, although I recognize that the order of importance may be different at other stations.

Analytical service means, naturally, the making of analyses for the purpose of furnishing information concerning the chemical composition of agricultural materials to farmers or other citizens of the State, or to other departments of the institution, and requires the ability to interpret the results or to determine in advance their probable value to the person who requests them. It is the possibility of the drawing of conclusions from analytical data which the facts do not at all warrant which leads me, personally, to object to the establishment of analytical laboratories in other departments where they will not be under the supervision of a trained thinker in the field of chemistry.

Sanitary and regulatory work comprises the whole field of investigation into the suitability of agricultural products for human use, and deals with the problems of water supplies, etc., as well as the administration of State and National laws governing the purity of or standards for agricultural products when offered for sale in the markets.

Agrotechnical control involves the study of the suitability of farm products for use as raw material to be manufactured into some more valuable product, and of the chemical principles underlying the processes to be used, as well as their control when in operation.

The three lines of work just briefly outlined are each legitimate and promising fields of study and thoroughly worthy of the best efforts of any research chemist. But it is the fourth, namely, biochemical research, which appeals most strongly to me personally, and to which I wish to devote this discussion.

The term "biochemistry" has only recently come into general use, even among chemists. As its etymology indicates,

it is that branch of chemistry which deals with vital processes, their mode of action and their products. Vital processes may be those of plants, animals, or men. A large amount of very valuable research in the chemistry of the living processes in men and animals has been carried on during the past two or three decades, by investigators who have been known as specialists in "physiological chemistry," "animal nutrition," etc. Relatively little has been done, however, in the study of the chemistry of the living processes in plants. A former president of this Society, himself an eminent student of plants, the late Dr. Charles E. Bessey, shortly before his death, commented on this fact to me and explained it by saying that "There have been few chemists who knew any botany and no botanists who knew any chemistry." Recently, however, a considerable number of students of biological chemistry have begun to turn their attention to this new field and most interesting and promising research problems have been opened up, to some of which I wish to call your attention.

Vital processes consist chiefly of reactions involving organic compounds—*i. e.*, compounds in which carbon, hydrogen, oxygen and nitrogen are the predominating elements —rather than the common inorganic elements which constitute the larger proportion of the mineral world. Naturally, then, the beginners in the study of the biochemistry of plants have made use of the methods of investigation which are commonly utilized by organic chemists. These methods may be grouped into three general classes, viz.: the isolation and identification of pure compounds, analysis (or the breaking down of compounds into simpler units of known composition) and synthesis (or the building of compounds from their constituent units). Fortunately, very great improvements have recently been made in the methods of accomplishing both the analysis and the synthesis of organic materials. The acid hydrolysis of proteins, with the subsequent separation and identification of the resulting aminoacids, as perfected by Van Slyke, and the improved methods of synthesis of carbohydrates and of artificial

proteins from their constituent units, as worked out by Emil Fischer and his students, have opened up fields of investigation of almost limitless possibilities. The application of these improved methods to the study of the fats, carbohydrates, proteins, pigments, tannins, and glucosides of plant tissues, together with the newer methods of study of catalytic action as represented by the group of peculiar substances known as "enzymes," and of the enormous activities induced by the colloidal condition, is rapidly bringing us nearer to an understanding of the processes which take place in nature's laboratory, the cell of a living organism. Such a knowledge is fundamental to a real understanding of the underlying principles of plant breeding for improvement in chemical composition, of disease resistance in plants, of response of crops to changes in environmental conditions, and a host of similar problems which constitute an important part of agricultural science. It is this opportunity to which I wished to call attention.

I now desire to cite a few examples of recent progress in this kind of investigation, as an illustration of how biochemistry may aid in the solution of problems of practical importance, and to point out certain other problems which lie just before us, to which the use of biochemical methods seems to me to be particularly fitted.

First, I may cite the work recently completed in our own laboratories on the relation of the chemical constitution of wheat proteins to the baking strength of flour. It has been known for a long time that wheat contains several different proteins, of which two—gliadin and glutenin—constitute the larger proportion and when united together form the gluten to which the ability of the dough to retain gas and so produce a "sponge" and bake into "light bread" is due. Many investigators have proposed many different methods of measuring the proportions of these two proteins which exist in any given sample of flour, and have expressed many different opinions concerning the relation of these proteins to the baking strength of the flour. Varying definite ratios between the proportions of these two proteins which

should be present in the flour to give it the optimum baking quality have been suggested. But no two investigators seemed to be able to get similar results from the same methods of investigation, and many tentative standards or theories concerning the relation of these proteins to baking strength were abandoned by their own proponents after further trial, because of the inconsistency of the results obtained at different times or under varying conditions.

Following the perfection of the Van Slyke process for the determination of the products of hydrolysis of proteins, however, it was found by Osborne and confirmed by our own investigations that these wheat proteins always yield definite percentages of cleavage products, which percentages are quite widely different in the case of the different individual proteins. It occurred to us that this fact might afford a ready means of determining accurately not only the proportions of the different proteins which are present in a given flour or the extracts or preparations made from it, but also of settling the question as to whether the proteins of flours of varying qualities were really different in character. A systematic investigation of this possibility soon gave conclusive evidence upon a number of points about which there had formerly been much argument, and we have already definitely established the following principles, namely: that the proteins in flours of all variations in baking strength are uniform in character; that the proportion of gliadin and glutenin which is present in flour and which enters into the formation of gluten is always the same, regardless of the physical characteristics of the gluten or the resultant baking quality of the flour; that the baking quality of the flour varies in direct relation to the proportion of non-gluten, or soluble, proteins present in it; and that the variations which former investigators had found so troublesome and so difficult to explain are due to the variable solubility of the proteins in the solvents used for extracting them from the material under investigation. It seems possible to work out from these principles, definite and fairly simple methods of measuring the baking quality of flour

and of estimating the flour-making value of different samples of wheat, matters which have been for a long time earnestly desired and sought by practical grain buyers, millers, and bakers.

As another example of the application of biochemical knowledge concerning the composition of proteins to the solution of practical agricultural problems, may be cited the recent studies, at several animal nutrition laboratories, of the function of the different amino-acid units from which proteins are synthetized in the nutrition of the body. For a long time, it had been thought that the feeding value of any crop material might be at least approximately judged if the proportion of protein, fats, and carbohydrates which it contained was determined by analysis, particularly if the analytical figures were corrected by certain coefficients of digestibility which had been experimentally determined. Based on this belief, tables of feeding standards were worked out with great care. Careful nutrition investigations soon showed, however, that proteins from different plant tissues are not equally efficient in promoting animal growth or even in maintaining animal life, and that rations which are accurately "balanced" so far as the usual feeding stuffs analysis will show, are wholly unsuited to the needs of the animal if deficient in certain constituents of the protein molecule which are essential to proper nutrition. The results of tests of various biochemical fractions of the protein molecule now well under way, seem to point to an early solution of the problem of what constitutes the "growth factor" in foods, as well as to the establishment of a more accurate understanding of the whole question of animal feeding.

A very interesting fact scientifically, and possibly of wide practical bearing, is the recent discovery by Willstätter and his students, that when subjected to the most improved methods of biochemical hydrolysis, chlorophyll, the active pigment of plants, and haemoglobin, the active pigment of animals, yield precisely the same degradation products; from which it appears that these two active energy-carriers

differ in composition only in that their constituent units are linked together by iron in the case of the blood pigment and by magnesium in the case of chlorophyll. This close similarity of the activators in metabolic processes leads to the hope that further close analogies between cell activities of plants and of animals may soon be discovered. If this hope is realized, a step nearer to the understanding of vital processes will have been taken.

Other interesting recent biochemical investigations, of which time will permit only the briefest mention, deal with the relation of molecular configuration of a carbohydrate to its fermentative and other biological properties (so definite a relation appearing that many investigators believe that the active principle of the microorganism must actually fit the fermentable material at all points as a glove fits the hand or as a key fits a lock); and the possibilities of the identification of proteins of differing plant origins by means of the anaphylaxsis, or similar reactions (for which some enthusiastic supporters have already claimed that these tests will ultimately form the basis of an entirely new and scientifically correct classification of plants, based upon chemical composition rather than upon external form or characteristics). These and many similar applications of the improved methods of study of organic compounds to the investigation of agricultural plant and animal products point the way, it seems to me, to a field of study into which experiment-station chemists may very properly enter and in which a multitude of new and promising problems present themselves.

I should not be presenting all that I had in mind at the outset of this discussion if I did not mention the large biochemical problem upon which we are now inaugurating work in the Division of Agricultural Chemistry at the Minnesota Experiment Station. I allude to our project entitled "The Biochemistry of Resistance to Disease in Plants." As you are all aware, there is now a very keen interest throughout the agronomic world in the production of disease-resistant strains, or varieties, of farm crops. Probably no other

single line of effort offers so attractive a field to the plant breeder, and it is certain that success in even a small portion of the efforts which are being made in this direction would result in enormous economic advantages to the crop producers of the country. The physiological or biochemical mechanism by which animal bodies resist the attacks of disease germs has been the object of much successful study during recent years and the knowledge so gained has been of enormous advantage to the human race. The toxins and antitoxins of animal pathology, the use of immune sera and the other applications of the results of this study, are familiar to every intelligent reader. Absolutely nothing is known, however, of the mechanism by which immune or resistant strains, or varieties, of plants protect themselves against the inroads of the parasites which work such frightful havoc upon their susceptible relatives. Are there phenomena in plants similar to those known to exist in animals whereby the host resists the effects of the parasite? Do plant cells protect themselves against the theft of their food material by the secretion of anti-bodies? Is there any indicator by means of which the plant breeder may recognize the ability of a particular plant to resist the attack of a fungous disease? These and a number of similar questions suggest the field of inquiry into which we propose to project our study.

The method of first attacking a problem of this sort which naturally suggests itself as being most likely to lead to a successful outcome is a comparative study, by the best biochemical methods which are available, of the physiological activities of normal and diseased plants. These activities are so many and the factors which influence them are so varied that anything like a complete study of them would occupy the time, attention and thought of a large number of investigators for a long period of time. Later studies will probably have to do with the reaction of the host to artificially prepared extracts which are biochemically similar to the composition of the cells of the parasite or its secretions, and of possible artificial stimulation, or of increase

by proper methods of plant breeding, of the parasite-resistant substances, if such be found. Whether an outcome of such study which will be ideally successful will ever be attained, cannot be prognosticated. But it is certain that much very interesting, and we hope valuable, information concerning the biochemical processes of normal and of diseased plant tissues will be accumulated as the work progresses.

It is because we recognize the enormity of the task, and have a strong faith in the ultimate value to agricultural science of intelligent work along this line, that I have presented the matter to you with the hope that such presentation may enlist the interest of, and create the desire to, participate in investigations of this sort, by several experiment-station chemists.

PLANT FOOD DEFICIENCIES OF COASTAL PLAIN AND PIEDMONT SOILS.

By C. B. Williams.

PLANT FOOD REQUIREMENTS OF SOME OF THE CHIEF SOIL TYPES OF THE COASTAL PLAIN AND PIEDMONT REGIONS.

In approaching the solution of this problem in North Carolina we have always located our experimental work on soils of known types and on soils which are important ones agriculturally in the sections in which the experiments are being conducted. These facts are determined by the soil survey which generally precedes in any area the taking up of systematically-planned field studies to determine the plant-food deficiencies of any type of soil. After the mapping is finished in the soil survey, an experienced man is sent over the area to draw representative samples from each type of soil for analyses. These are sent in to the chemical laboratory for a determination of the total amounts of nitrogen, phosphoric acid, and potash.

What Chemical Analyses Show.—From such an examination it will be possible to calculate the total amounts of these plant-food constituents present in the soil, but it will not be possible to determine the availability of these from such an examination. This can only be satisfactorily determined by carefully conducting well-planned fertilizer experiments with crops on each type of soil a sufficient length of time to eliminate seasonal and other factors that might come in to interfere with a fair deduction from the results. In Table I will be found recorded the average amounts of nitrogen, phosphoric acid and potash in the types of soil on which the experimental work in North Carolina has thus far been conducted. In the Coastal Plain section the Norfolk series embraces decidedly the most important soils; while in the Piedmont section the Cecil series occupies the greatest area and are the soils of the greatest importance agriculturally. The data in this table shows very strikingly

that the total amounts of phosphoric acid and nitrogen present in all the types of soil on which the experimental fields are located are each much smaller than is the amount of potash. From these facts alone with reference to the different types of soil under consideration, the only inferences that could safely be made would be that potentially all the soils are well supplied with potash, but that the amounts of phosphoric acid and nitrogen, one or the other or both, are at the present time, or soon will be, limiting factors in the production of large crops.

TABLE I.—AVERAGE COMPOSITION OF SOME OF THE LEADING SOILS IN THE COASTAL PLAIN AND PIEDMONT REGIONS.

Type of Soil.	Average No. lbs. plant food in surface 6 2-3 in. of soil per acre.			Field. Experimental
	Nitrogen.	Phosphoric Acid.	Potash.	
Coastal Plain Soils				
Portsmouth fine sandy loam	1,660	590	7,051	Pantego.
Portsmouth silt loam	1,131	555	28,884	Edenton.
Norfolk sand	1,275	298	1,978	Greenville.
Norfolk fine sandy loam	912	546	8,873	Edgecombe
Norfolk sandy loam	639	1,439	4,552	Goldsboro.
Piedmont Soils				
Cecil clay	1,285	1,430	17,743	Charlotte No. 1.
Iredell loam	909	2,238	4,247	Charlotte No. 2.
Cecil sandy loam	801	571	49,260	Gastonia.
Cecil loam	865	1,512	27,702	Iredell.

The economical increase of the nitrogen supply of all these soils for the production of general crops like corn, cotton, or oats will have to be brought about largely by the growing of leguminous crops in rotation with these and possibly other general field crops and turning a part of these into the soil for soil improvement. By this means, as mentioned above, not only can the nitrogen supply of the soils be kept up wholly or largely, but the soils be kept in good physical condition by the organic matter turned into the soil. It will probably be necessary on most of the soils where this practice is followed to add lime in liberal amounts at intervals of four to six years. On the other hand, in the case of phosphoric acid its supply in the soil will have to be kept up by additions of some material like acid phosphate, phosphate rock or ground bone, if large crops are expected to be produced. In some of these soils the total amount of phosphoric acid is very low. Potentially, the Iredell loam is the type given that is richer in phosphoric acid.

What Fertilizer Experiments in Field Show.—For the five fields in the Coastal Plain section and the four fields of the Piedmont section the following deductions which will have wide application throughout the Southern States, may be made from the data contained in Tables II and III:

TABLE II—AVERAGE RESULTS OF FERTILIZER EXPERIMENTS WITH DIFFERENT CROPS GROWN ON DIFFERENT SOILS

Fertilizer Application	Average Increase in Yield per Acre Over Unfertilized Plat on Different Fields																			
	Coastal Plain Section													Piedmont Section						
	Pantego			Edenton			Green-ville	Edgecomb			Goldsboro			Charlotte No. 1		Charlotte No. 2		Gastonia		
	Seed Cotton	Corn	Irish Pota-toes	Seed Cotton	Corn	Vetch & Oat Hay	Corn	Seed Cotton	Corn	Oat & Vetch Hay	Seed Cotton	Corn	Oat & Vetch Hay	Seed Cotton	Corn	Seed Cotton	Corn	Seed Cotton	Corn	Wheat
	Lbs.	*Bus.*	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*	*Lbs.*	*Bus.*	*Lbs.*	*Lbs.*	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*	*Bus.*	*Bus.*
L . . .	—155	5.4	10.2	225	2.1	470	9.4	—110	—0.9	—200	230	1.3	984	127	7.5	230	1.6	80	4.0	0.9
N . .	75	29.8	17.2	405	—2.1	1330	22.5	195	27.4	2100	—410	22.4	984	172	6.9	510	50.1	—50	9.6	1.8
P . . .	—165	1.5	14.7	525	9.3	810	0.5	40	1.4	—500	70	—0.6	147	67	6.6	40	0.6	355	13.5	3.8
K . .	125	—1.0	—24.3	55	1.9	—260	0.5	280	—4.3	200	—70	0.0	927	67	3.2	230	2.0	305	5.3	8.5
NP . .	—140	27.4	18.5	490	23.9	2320	15.6	275	24.5	1900	270	19.3	1056	75	8.7	450	44.4	580	22.1	17.4
NK . .	350	26.9	16.0	90	—0.4	960	23.4	480	28.5	2400	110	28.3	2255	265	4.2	700	49.8	300	10.3	3.9
PK . .	380	10.2	29.2	785	8.7	370	—3.8	380	—8.9	—100	270	0.1	810	—53	1.1	110	—0.9	290	5.1	0.9
NPK .	380	30.3	—2.0	1645	18.1	2150	19.4	480	36.4	2400	930	25.7	2137	67	6.1	830	54.7	465	16.9	18.8
LNPK	590	35.0	26.6	3425	15.0	2250	16.5	620	42.8	2500	1970	31.9	3218	37	7.3	840	45.7	705	19.2	16.9

COASTAL PLAIN SOILS.

Pantego Field.—The chief deficiency of the Portsmouth fine sandy loam type of soil is nitrogen in available form. Next in importance is lime and phosphoric acid.

Edenton Field.—For the Portsmouth silt loam type of soil the plant-food constituents producing the greatest returns are phosphoric acid, nitrogen and lime in the order given.

Greenville Field.—For the Norfolk sand type of soil as represented by this field the chief deficiencies are shown by our results to be: first, nitrogen; second, lime; and, third, potash.

TABLE III—GAINS RESULTING FROM DIFFERENT FERTILIZING CONSTITUENTS USED ALONE AND IN COMBINATIONS ON DIFFERENT TYPES OF SOILS.

	Coastal Plain Section													
	Pantego			Edenton			Greenville	Edgecombe			Goldsboro		
	Seed Cotton	Corn	Irish Potatoes	Seed Cotton	Corn	Oat & Vetch Hay	Corn	Seed Cotton	Corn	Oat & Vetch Hay	Seed Cotton	Corn	Oat & Vetch Hay
	Lbs.	*Bus.*	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*	*Lbs.*	*Bus.*	*Lbs.*
Gain for N alone	75	29.8	17.2	405	—2.1	1330	22.5	195	27.4	2100	—410	22.4	984
Gain for N with P	—25	25.9	3.8	—35	14.6	1510	15.1	235	23.1	2400	200	19.9	909
Gain for N with K	220	27.9	40.3	145	—2.3	1220	22.9	200	32.8	2200	180	28.3	1328
Gain for N with P & K	0	20.1	—31.2	860	9.4	1780	23.2	100	45.3	2500	660	25.8	1327
Average Gain for N	68	25.9	7.5	344	4.9	1460	20.9	183	32.2	2300	158	24.1	1137
Gain for P alone	—165	1.5	14.7	525	9.3	810	0.5	40	1.4	—500	70	—0.6	147
Gain for P with N	—215	—2.4	1.3	85	26.0	990	—6.9	80	—2.9	—200	680	—3.1	72
Gain for P with K	255	11.2	53.5	840	6.8	630	—4.3	100	—4.6	—300	340	0.1	—117
Gain for P with N & K	30	3.4	—18.0	1555	18.5	1190	—4.0	0	7.9	0	820	—2.6	—118
Average Gain for P	28	3.4	10.4	751	15.2	905	—3.7	55	0.5	—250	478	—1.6	—4
Gain for K alone	125	—1.0	24.3	—55	1.9	—260	0.5	280	—4.3	200	—70	0	927
Gain for K with N	275	—2.9	—1.2	—315	1.7	—370	0.9	285	1.1	300	520	5.9	1271
Gain for K with P	545	8.7	14.5	260	—0.6	—440	—4.3	340	—10.3	400	200	0.7	663
Gain for K with N & P	520	2.9	—20.5	1155	—5.8	—170	3.8	205	11.9	500	660	6.4	1081
Average Gain for K	366	1.9	—7.9	261	—0.7	—310	0.2	278	—0.5	350	328	3.3	986
Gain for L alone	—155	5.4	10.2	225	2.1	470	9.4	—110	—0.9	—200	230	1.3	984
Gain for L with NPK	210	4.7	28.6	1780	—3.1	100	—2.9	140	6.4	100	1040	6.2	1081
Average Gain for L	28	5.1	19.4	1003	—0.5	285	3.3	15	2.8	—50	635	3.8	1033

TABLE III (CONTINUED)—GAINS RESULTING FROM DIFFERENT FERTILIZING CONSTITUENTS USED ALONE AND IN COMBINATIONS ON DIFFERENT TYPES OF SOILS.

	Piedmont Section.											
	Charlotte No. 1		Charlotte No. 2		Gastonia			Iredell				
	Seed Cotton	Corn	Seed Cotton	Corn	Seed Cotton	Corn	Wheat	Seed Cotton	Corn	Oat Hay	Wheat	R. Clover Hay
	Lbs.	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*	*Bus.*	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*	*Bus.*	*Lbs.*
Gain for N alone	172	6.9	510	50.1	—50	9.6	1.8	105	5.6	700	—0.9	1200
Gain for N with P	8	2.1	410	43.8	225	8.6	13.6	—95	5.3	1260	—6.8	4600
Gain for N with K	198	1.0	470	47.8	—5	5.0	—4.6	335	8.1	700	1.9	5000
Gain for N with P & K	120	5.0	720	55.6	175	11.8	17.9	45	3.3	1380	9.8	6400
Average Gain for N	125	3.8	528	49.3	86	8.8	7.2	98	5.6	1010	1.0	4300
Gain for P alone	67	6.6	40	0.6	355	13.5	3.8	340	7.7	1000	14.3	200
Gain for P with N	—97	1.8	—60	—5.7	630	12.5	15.6	140	7.4	1560	8.4	3600
Gain for P with K	—120	—2.1	—120	—2.9	—15	—0.2	—7.6	175	8.8	160	—4.3	800
Gain for P with N & K	—198	1.9	130	4.9	165	6.6	14.9	—115	4.0	840	3.6	2200
Average Gain for P	—87	2.1	—3	—0.8	284	8.1	6.8	135	7.0	890	5.5	1700
Gain for K alone	67	3.2	230	2.0	305	5.3	8.5	—5	—0.4	60	2.0	—1000
Gain for K with N	93	2.7	190	—0.3	350	0.7	2.1	225	2.1	60	4.8	2800
Gain for K with P	—120	—5.5	70	—1.5	—65	—8.4	—2.8	—170	0.7	—780	—16.6	—400
Gain for K with N & P	—8	—2.6	380	10.3	—115	—5.2	1.4	—30	—1.3	—660	0.0	1400
Average Gain for K	8	—1.9	218	2.6	119	—1.9	2.3	5	0.3	—330	—2.5	700
Gain for L alone	127	7.5	230	1.6	80	4.0	0.9	—155	1.8	250	—3.0	260
Gain for L with NPK	—30	1.2	10	—9.0	240	2.3	—1.9	45	1.5	1300	—3.9	—500
Average Gain for L	49	4.4	120	3.7	160	3.2	0.5	—55	1.7	775	—3.5	—120

Edgecombe Field E.—For the Norfolk fine sandy loam soil of this farm, the main deficiencies have been shown by field experiments to be: first, nitrogen; second, potash; and, third, phosphoric acid and lime. This type of soil is one of the largest in extent and importance of all the Coastal Plain soils.

Goldsboro Field.—In experiments on the Norfolk sandy loam soil of this farm it has been shown that the chief plant-food requirements are for nitrogen, lime and potash in the order given. Phosphoric acid when used seems to have on an average caused a decrease in yield of all the crops except in the case of cotton.

Ordinarily with all the Norfolk series of soils of the Coastal Plain region phosphoric acid and potash give little or no increase in crop yields until nitrogen has been added to the soil.

PIEDMONT SOILS.

Charlotte Field No. 1.—The chief deficiencies of the Cecil Clay soil of this farm were shown by results in Tables II and III to be nitrogen, lime and phosphoric acid.

Charlotte Field No. 2.—The chief plant-food requirements of the Iredell loam type of soil has been shown to be: first, nitrogen decidedly; and, second, potash. On an average, as will be seen in Table III, phosphoric acid has seemed to decrease rather than prove beneficial when applied to this type of soil.

Gastonia Field.—Nitrogen, phosphoric acid and lime have been shown to be the chief requirements of the Cecil sandy loam of this field,

Iredell Field E.—In the production of grain and seed cotton on the Cecil loam soil of this farm, phosphoric acid was found to be the chief deficiency while applications of nitrogen gave the greatest response when hays were grown. Practically no gains on an average were secured from the use of lime and potash, except in the case of lime, in the growing of oats for hay, and in the case of potash in growing red clover for hay.

SUMMARY OF RESULTS.

Taking the field results as a whole, which no doubt have wide application to soils throughout the South Atlantic States, it will be seen that the limiting constituents of plant growth for the leading types (Norfolk and Portsmouth Series) of soil in the Coastal Plain Region are generally: first, nitrogen; and, second, potash and lime; and for those (Cecil Series) of chief importance and extent in the Piedmont Region: first, is phosphoric acid; and, second, is nitrogen. Without the addition of these lacking plant-food constituents, it will be impossible to grow large crops for any great length of time, for with most of the types of soil of these two regions the growth of twenty-five- to thirty-one-hundred-bushel crops of corn would require an amount of phosphoric acid and nitrogen equal to the total amount of these two constituents contained in most of the Coastal Plain and Piedmont soils.

FERTILIZER MATERIALS USED.

In the formulas given in Tables II and III, N stands for nitrogen from dried blood; P for phosphoric acid from acid phosphate; K for potash from sulphate of Potash; and L for 2,000 pounds of ground limestone per acre.

The normal (NPK) fertilizer application per acre for each crop is based upon the amounts of the fertilizing constituents removed in the following yields per acre of each crop which are assumed to be sold from the farm:

Corn	100	bus. grain and 3 tons of dry stover.
Cotton	3,000	lbs. of seed cotton.
Wheat	50	bus. grain and 2½ tons of straw.
Oats	75	bus. grain and 2 tons of straw.
Irish potatoes	300	bus.

RURAL CREDITS FOR PORTO RICO.

By D. W. May.

Now that federal legislation on rural credits seems imminent, it behooves us in each State and Territory of the United States to set our house in order to the end that we may take advantage of the benefits to accrue with the least delay and friction. Public sentiment at first looked on the proposed legislation with suspicion, but later with the propaganda made by certain elements over enthusiasm developed and Congress became almost guilty of hasty legislation in extending rural credits. The pendulum is now swinging back and it seems proable that the coming session of Congress will see the enactment of wise and conservative legislation in the matter.

The three elements of a loan, and they are so trite as to hardly need repetition, are safety, convertibility, and return. The greater the first two elements are conserved, the lower the rate of interest. Bonds paid from taxes and underlying railroad bonds are the highest example of these and the rate on them is the lowest obtainable, being around four per cent. The rate on farm loans has been falling steadily until now money in many of the States can be obtained at from five to six per cent.

Many schemes have been proposed for reducing the rate of interest on farm loans. These have varied from the issue of money based on land to the guarantee of the government of principal and interest on farm loans. Manifestly some of these proposals would lead to disaster, as they have in the past, for such schemes are not new.

Farm loans properly made should be as secure as the best municipal and railroad bonds and should be made as attractive to the investor. It should be the rôle of a national law to so safeguard by wise legislation the issuance and recording of farm loans as to put them in the same class

with the best bonds on the market. With the large amount of capital in the country seeking investment and the safety of farms as a security, the machinery whereby the two may be brought together should easily lower the cost to the borrower and give to the lender absolute safety besides the element in which the farm loan is usually lacking; namely, convertibility.

The legal aspects of farm credits in Porto Rico are unique. The island was taken over from Spain in 1898 and the old Spanish laws of land tenure then obtaining have been modified by legislation where elements of the Roman law, on which Spanish law is based, and the English common law have been combined. Titles are somewhat unsettled, boundaries not always clearly defined and the transference and mortgaging of land cumbersome and expensive. The legal rate of interest is high,—12 per cent.,—and that is the minimum rate usually obtaining in farm loans. Added to this are the stamp taxes on legal papers and the notarial fees so that in making even a small loan the borrower pays fifteen or twenty dollars in fees and taxes.

Land loans in Porto Rico have been and are safe when not made in excess of the value of the land; the interest return is large and mortgages are not taxed. An effort toward convertibility has been attempted by a law that permits making of notes payable to bearer secured by mortgage. What is needed to reduce the cost of money to the borrower is a guarantee of titles and a lessened cost of making and recording mortgages. To bring this about, a modified Torrens system should be adopted and all lands listed thereunder with the guarantee of the government back of them. Then the borrower and lender could go before the registrar and carry through their negotiations as readily as the owner can take his gilt-edge railroad bond to the bank and secure a loan on it. Values could be based on the assessment of the land for taxation; the government should supervise the issuance of a convertible debenture, guarantee the title, and eliminate all unnecessary expense and delay. The lender should be able to determine from

the assessed value the amount he would loan on the property in question and the borrower, having met the requirements of safety and convertibility, should be able to obtain his loan at the lowest rates prevailing.

Capital can be had in Porto Rico under proper safeguards. It should be the province of the island government to make these safeguards available. Attempts of the insular government to borrow money to lend again would result in chaos and should be avoided, but all facilities to bring borrower and lender together with the least cost and delay is the safest and best rôle for the government to play.

Our people have never learned to coöperate and the system of landschafts would not succeed in Porto Rico. Our population, made up as it is of various racial elements, the guarantee of a loan by a unity of interest would not find favor. The land is assessed for taxation at its full value and this forms a good basis for arriving at a conservative amount to loan upon the property. With a government guarantee of title the element of safety would be met. Retaining the present law permitting the issuance of notes payable to bearer secured by mortgage would give convertibility to the loan. These two factors provided for, the rate could be adjusted between borrower and lender which would certainly be at a much less cost to the former than under methods now obtaining. While not Utopian, this arrangement is for the present workable and would be a long step toward our planters getting for both long and short periods at a low rate the capital that they so sorely need.

CHARLES EDWIN BESSEY.

Charles Edwin Bessey, son of Abnah and Margaret Bessey, was born May 21, 1845, in Milton Township, Wayne County, Ohio, and died February 25, 1915, at Lincoln, Nebraska. After finishing the country school, he entered the Academy at Seville. By teaching school winters and attending the Academy as opportunity offered, he prepared himself for college. In July, 1866, he entered the freshman class of the Michigan Agricultural College. During his college course he taught school during the winter, as was the custom with many of the college students. During his Junior year in college, largely through the influence of President Abbott, he was led to choose Botany as his life work. Upon graduation he was appointed Assistant in Horticulture at the Michigan Agricultural College and put in charge of the greenhouse. In December, 1869, he was offered an instructorship in Botany and Horticulture at the Iowa Agricultural College and began his work there in February, 1870. The following year he was promoted to the position of Adjunct Professor. In Iowa, he took an active interest in the various farmers' organizations and in the State teachers' associations. In September, 1872, he attended the meeting of the American Society for the Advancement of Science, of which he was elected a member. It was here he met for the first time Dr. Asa Gray, Dr. Asa How, Dr. Alexander Winchell, and others. During the following winter he spent three months at Cambridge, Massachusetts, studying under Dr. Gray. He was appointed to the chair of Botany and Zoology of the Iowa Agricultural College in 1873. In 1875, he was made President of the Iowa Academy of Sciences, of which he was the chief founder, being elected regularly for several years. In 1877 and 1878, he wrote and published a geography of Iowa. At this time he began work on the "*Botany for High Schools and Colleges*," one of the American Science Series textbooks. In June of 1879, he was granted the degree of

Doctor of Philosophy by the Iowa State University, in recognition of his publications on Botany. In July, 1881, he gave the first course in Botany in which laboratory work was offered at the University of Minnesota Summer School of Science. The compound microscopes used for that occasion were borrowed from the Iowa Agricultural College, as the University of Minnesota possessed no such microscopes. In 1884, the briefer course of his botany entitled *"Essentials in Botany"* appeared and passed through seven editions, the eighth edition appearing in 1914.

In August, 1884, he was elected to the position of Dean of the Industrial Faculty and Professor of Botany and Horticulture at the University of Nebraska, which position he accepted. In March, 1888, he was elected President of the Nebraska State Teachers' Association. During the summer of 1888, accompanied by his wife, he went to Europe and spent some time at the Kew Gardens in London. The trip was cut short somewhat by his appointment as Acting Chancellor of the University of Nebraska. He was made President of the Society for the Promotion of Agricultural Science in 1889 and of the Western Society of Naturalists in October of the same year. He continued as Acting Chancellor of the University until June, 1891, when he secured the appointment of Professor Canfield as Chancellor. In December, 1891, he was elected President of the Nebraska Academy of Science, of which he had been active in founding. In 1892 he began work as Botanical Editor for *Johnson's Cyclopedia*. He was one of the charter members of the Botanical Society of America, of which he was elected President in 1895. In July, 1895, he was appointed Director of the University of Nebraska Summer School and continued in this position during '96 and '97. In 1898 he was granted the degree of Doctor of Laws by the Iowa College. In 1899 he was again made Acting Chancellor of the University of Nebraska, which position he filled for one year. In 1902 he was elected President of the American Microscopical Society. In 1909 he was made head Dean of the University of Nebraska. In December, 1910, at the

Minneapolis meeting of the American Association for the Advancement of Science he was elected President.

One of his services to be particularly noted was the introduction in 1873, at the Iowa Agricultural College, of the laboratory method of teaching Botany with the use of the compound microscope.

In the early eighties, as a member of the Society for the Promotion of Agricultural Science, he was consulted regarding the proposition to establish Government support for agricultural experiment stations, and he wrote the paragraph concerning the duties of such relations as it was adopted and later made a part of the Hatch Act.

He was married in 1873 to Lucy Atherain, of West Tisbury, Marthas Vineyard, Massachusetts. To them were born three sons, of whom the oldest, Edward, was Assistant Professor in charge of the Electrical Engineering Course at the Colorado Agricultural College at the time of his death in 1910. The second son, Ernest, since 1910 has been Professor of Botany at the Michigan Agricultural College, his father's Alma Mater; and the third son, Carl, is an Electrical Engineer in Chicago.

EUGENE WALDEMAR HILGARD.

Eugene Waldemar Hilgard, known throughout the civilized world for his researches in the scientific agriculture, was born in Zweibrucken, Bavaria, January 5, 1833, and died in Berkeley, California, on January 8, 1916, three days after having celebrated his 83rd birthday. When three years old, he came to America with his parents and settled on a farm near Belleville, Illinois, where he received his early education from his father. He returned to Germany when sixteen years old, and, after studying at Zurich and the Royal Mining School at Freiberg, he graduated at Heidelberg, receiving his degree of Ph. D. in 1853. After a time spent on the coast of Spain, he returned to America and was appointed Assistant State Geologist of Mississippi in 1855. In 1857, that survey was suspended and he was appointed Chemist of the Smithsonian Institution and Lecturer on Chemistry in the National Medical College in Washington, D. C. In 1858, he received the appointment of State Geologist of Mississippi and held that position until 1866, when given the chair of Chemistry in the University of Mississippi. In 1873, he accepted the professorship of Mineralogy, Geology, Zoology and Botany in the University of Michigan, but resigned in the spring of 1875 and came to the University of California as Professor of Agricultural Chemistry, and Director of the State Agricultural Experiment Station. In 1901, he resigned the latter position and was made Emeritus Professor of Agriculture by the Board of Regents of the University.

Prof. Hilgard entered the field of scientific investigation at the age of 22, well prepared for that long life of research into the various factors of soil fertility and plant life that brought to him world-wide fame and many honors. A scientist in the true sense, because of his thorough training in the natural sciences as well as in culture courses, with his knowledge of several foreign languages, the extreme care, accuracy and attention to detail which he gave to everything he undertook and his untiring energy and enthu-

siasm in the prosecution of the various problems, it is not surprising that the results of his observations and his conclusions have stood the test of time and verification. Even his geological work in Mississippi, undertaken when a young man at the very beginning of his career, and in which he was the first to recognize, outline, and name a number of new formations in that State, and later over the entire Mississippi embayment region, has been verified, and his report of 1860 still stands as a recognized authority by all geologists.

It was during his geological field work in Mississippi that his observations caused him to become interested in the relation of soil characters to plant life; and he was the first to note that the flora of a locality was a guide to the character of the soil and to the nature of the underlying geological strata. He was the first to interpret the results of chemical and physical analyses with respect to plant life, soil productiveness and soil durability, and to insist that the complex nature of a soil requires a study of combined chemical, physical mineralogical, geological and biological characters if we would thoroughly understand it.

He made a geological reconnoissance of Louisiana, and special examinations of the Mississippi River delta, the mud-lumps of the passes and the rocksalt and sulphur deposits of Petite Anse Island; also an agricultural survey for the Northern Transcontinental Railroad.

He established the Agricultural College and Experiment Station of California in the spring of 1875, built it up, popularized it, and placed it upon a permanent basis before his retirement as Dean and Director, in 1904, when he was made Emeritus Professor of Agriculture.

He was the first to draw attention to the remarkable soils of the arid region as exemplified in California, their great depth, their richness in plant-food elements, the absence of a subsoil, even at a depth of several feet, their excellent texture because of the absence of an excess of clay, except in certain localities, the great depth to which roots of trees and plants descend under natural conditions, and the stocky

form assumed by trees because of the abundance of lime in the soil. He prepared for the U. S. Weather Bureau, in 1892, a discussion of the "Relations of Climate to Soils," which was translated into several European languages. He was the first to study the occurrence and nature of alkali salts in arid lands, their movement or rise and fall under climatic conditions, their effect on vegetation, and the means to be used for their neutralization and removal from the land. The bulletins giving the results of these studies have been published in other countries that have alkali lands.

The bibliography of Prof. Hilgard contains many noted publications; among them his report on the *Geology and Agriculture of Mississippi,* a volume of 390 pages; his report on *Cotton Production in the United States,* with detailed descriptions of the geology, soils and topography of the cotton-producing States, written for the Tenth U. S. Census, volumes 5 and 6; and his book of 600 pages on *Soils of the Arid and Humid Regions,* which he regarded as a summary of his life's work on that subject, are the most prominent.

Many honors were showered on Professor Hilgard; the degree of LL.D. was conferred by the Universities of Mississippi, Michigan, Columbia, and California; the University of Heidelberg re-conferred on him the degree of Ph.D. on the fiftieth year after his graduation; the Liebig medal from the Munich Academy of Sciences was given "for important advances in agricultural science," and he received other medals from the expositions of Paris, Rio de Janeiro, and St. Louis. President Harrison offered him the position of Assistant Secretary of Agriculture, but he was compelled to decline.

Professor Hilgard was a man of great energy and activity in the cause of agricultural science; and during the last three years of his life, when his vitality was greatly reduced because of an injury, even to the last few days his daily wish was that he might be spared for continued service.

Past Presidents.

Term began		*Expired*
1880	W. J. Beal, *of Michigan*	1882
1881	W. H. Brewer, *of Connecticut*	1884
1884	H. E. Alvord, *of New York*	1886
1886	E. L. Sturtevant, *of New York*	1887
1887	R. C. Kedzie, *of Michigan*	1889
1889	C. E. Bessey, *of Nebraska*	1891
1891	I. P. Roberts, *of New York*	1893
1893	W. Saunders, *of Ontario, Canada*	1895
1895	W. R. Lazenby, *of Ohio*	1897
1897	B. D. Halsted, *of New Jersey*	1899
1899	W. J. Beal, *of Michigan*	1901
1901	W. H. Jordan, *of New York*	1903
1903	William Frear, *of Pennsylvania*	1905
1905	H. P. Armsby, *of Pennsylvania*	1907
1907	T. F. Hunt, *of Pennsylvania*	1909
1909	S. M. Tracy, *of Mississippi*	1911
1911	Eugene Davenport, *of Illinois*	1913
1913	H. J. Waters, *of Kansas*	1915
1915	Charles E. Thorne, *of Ohio*	

Past Secretaries.

1880	E. L. Sturtevant, *of Massachusetts*	1882
1882	G. C. Caldwell, *of New York*	1883
1883	F. A. Gulley, *of Mississippi*	1885
1885	B. D. Halsted, *of Iowa*	1886
1886	W. R. Lazenby, *of Ohio*	1891
1891	L. O. Howard, *of District of Columbia*	1893
1893	W. Frear, *of Pennsylvania*	1895
1895	C. S. Plumb, *of Indiana*	1899
1899	T. F. Hunt, *of Ohio*	1900
1900	F. M. Webster, *of Illinois*	1905
1905	F. W. Rane, *of Massachusetts*	1910
1910	E. W. Allen, *of District of Columbia*	1914
1914	L. A. Clinton, *of District of Columbia*	

MEMBERSHIP OF THE SOCIETY.

Honorary Member.

1899. Hon. James Wilson, LL. D., *Traer, Iowa.*

Regular Members.

(Arranged Alphabetically.)

The prefixed date is the year of election.

1907. Edwin West Allen, B. S. (Mass. Agri. Coll. and Boston Univ., '85), Ph. D. (Göttingen, '90); *U. S. Dept. Agri., Washington, D. C.;* Asst. Chem. Mass. Expt. Sta., '85–'88; Asst. Office Ext. Stas., '90–'93; Asst. Dir., do., '93—; Ed. Expt. Sta. Record, '95—.

1913. Harry Orson Allison, B. S. (Univ. Ill., '06), M. S. (do., '06); *Columbia, Mo.;* Instr. and Asst. in Anim. Husb., Univ. Ill., and Expt. Sta., '06–'10; Asst. Prof. Anim. Husb., Univ. Mo., '10–'12; Assoc. Prof., do., and Anim. Husb. Mo. Expt. Sta., '12—.

1913. John W. Ames, B. S. (Case School Appl. Sci., '98), M. S. (do. '06); *Wooster, Ohio;* Chem., Ohio Expt. Sta., '99—.

1889. Henry Prentiss Armsby, B. S. (Worcester Poly. Inst., '71), Ph. B. (Sheffield Sci. School, '74), Ph. D. (Yale Univ., '79), LL. D. (Univ. Wis., '04); *State College, Pa.;* Chem. Conn. Expt. Sta., '77–'81; Vice Prin. Storr Agr. School, '81–83; Prof. Agr. Chem., Univ. Wis., '83–'87; Dir. Pa. Expt. Sta., '87–'07; Dean School of Agri., Penn. State College, '95–02; Dir. Inst. Animal Nutrition, '07—.

1886. Joseph Charles Arthur, B. S. (Iowa State Coll., '72), M. S. (do., '77), D. Sc. (Cornell Univ., '86); *Lafayette, Ind.;* Instr. Biol., Iowa State Coll., '76–'78; Instr. Bot., Univ. Wis., '79–'81; do., Univ. Minn., '82; Bot. N. Y. Expt. Sta., '84-'87; Prof. Bot., Purdue Univ., '87–'88; Prof. Veg. Phys. and Path., do., and Bot., Ind. Expt. Sta., '88–'15; Prof. Emeritus Bot., Purdue Univ., '15—.

1906. Liberty Hyde Bailey, B. S. (Mich. Agr. Coll., '82), M. S. (do., '85), LL. D. (Univ. Wis., '07); *Ithaca, N. Y.;* Prof. Hort. and Landscape Gardening, Mich. Agr. Coll., '84–'88; Prof. Hort., Cornell Univ., '88–'03; Dir. Coll. Agr. and Expt. Sta., Cornell Univ., '03–'13; Editor and writer, '13—.

1914. Elmer Darwin Ball, B. S. (Iowa St. Coll., '95); M. S. (do., '98); Ph. D. (Ohio State Univ., '07); *Logan, Utah;* Asst. in Zool. and Ent., Iowa St. Coll., '95–'97; Asst. in

Zool. and Ento., Colo. Agr. Coll., '97–'02; Prof. Zool. and Ento., Utah Agr. Coll., '02–'07; Dean School Agr. and Dir. Expt. Sta., Utah Agr. Coll., '07—.

1879. WILLIAM JAMES BEAL, A. B. (Univ. Mich., '59), A. M. (do., '63), Sc. B. (Harvard Univ., '65), Sc. M. (Univ. Chicago, '75), Ph. D. (Univ. Mich., '80), D. Sc. (Mich. Agr. Coll., '05); *Amherst, Mass.;* Prof. Bot., Mich. Agr. Coll., '70–'72; Prof. Bot. and Hort., '72–'81; Prof. Bot. and Forestry, '81–'03; Prof. Bot., '03–'10; Prof. Emeritus, '10—.

1912. AUGUSTINE WILBERFORCE BLAIR, B. S. (Haverford, '92), A. M. (do., '96); *New Brunswick, N. J.;* Prof. Chem., Guilford Coll., '96–'97; Asst. Chem., N. C. Expt. Sta., '97–'98; State Chem., N. C., '98–'99; Asst. Chem., Fla. Expt. Sta. and Univ. Fla., '99–'06; Chem., Fla. Expt. Sta., '06–'12; Assoc. Soil Chem., N. J. Expt. Sta., '12—.

1913. MAURICE ADIN BLAKE, B. S. (Mass. Agr. Coll., '04); *New Brunswick, N. J.;* Asst. Hort., R. I. Agr. Coll. and Expt. Sta., '04–'05; Instr. Hort., Mass. Agr. Coll., '05–'06; Hort., N. J. Expt. Stas., '06—.

1893. HENRY LUKE BOLLEY, B. S. (Purdue Univ., '88), M. S. (do., '89); *Agricultural College, N. Dak.;* Instr. Biol. and Asst. Bot. to Expt. Sta., Purdue Univ., '90; Prof. Bot. and Plant Path., N. Dak. Agr. Coll. and Bot. and Plant Path. of Expt. Sta., do., '90—.

1909. WILLIAM PENN BROOKS, B. Sc. (Mass. Agr. Coll., '75), Ph. D. (Halle, '97); *Amherst, Mass.;* Prof. Agr. Imp. Coll. Agr., Sapporo, Japan, '77–'88; Prof. Bot., do., '81–'88; Pres., do., *ad interim* '80–'83 and '86–'87; Prof. Agr. and Agr., Mass. Agr. Coll. and Expt. Sta., '89–'09; acting Pres. and Dir., do., '05–'06; Dir. Expt. Sta., '06—.

1905. BURT C. BUFFUM, B. S. (Col. Agr. Coll., '90), M. S. (do., '93); *Worland, Wyo.;* Asst. Met. and Irr. Eng., Col. Agr. Coll., '90–'91; Prof. Hort. and Met., Univ. Wyo. and Bot. Wyo. Expt. Sta., '91–'92; Prof. Agr. and Hort., do., '91–'00; Vice Dir. do. Expt. Sta., '96–'00; Prof. Agr., Col. Agr. Coll., '00–'02; Dir. Wyo. Expt. Sta., and Prof. Agr. and Hort., Univ. Wyo., '02–'07; Plant Breeder and Mgr. Wyo. Seed Breeding Co., '07—.

1901. EDGAR ALLEN BURNETT, B. S. (Mich. Agr. Coll., '87); *Lincoln, Nebr.;* Asst. Mich. Agr. Coll., '89–'93; Prof. Anim. Husb., S. Dak. Agr. Coll., '96–'99; Prof. Anim. Husb., Univ. Nebr., '99–'07; Dir. Nebr. Expt. Sta., '01—; Dean Coll. Agr., '09—.

1908. KENYON L. BUTTERFIELD, B. S. (Mich. Agr. Coll., '91), A. M. (Univ. Mich., '02); *Amherst, Mass.;* Supt. Mich. Farmers'

Institutes, '95–'99; Instr. Univ. Mich., '02; Pres. Rhode Island Coll., '03–'06; Pres. Mass. Agr. Coll. and Head Div. Rural Sociol., '06—.

1909. FRANK KENNETH CAMERON, A. B. (Johns Hopkins, '91), Ph. D. (do., '94); *Washington, D. C.;* Fellow Cornell, '94–'95; Assoc. Prof., Catholic Univ., '95–'97; Asst. Physical Chem., Cornell, '97–'98; Expert, U. S. D. A., '98–'99; Soil Chemist, do., '99—.

1914. IRA DETRICK CARDIFF, B. S. (Knox Coll., '99); Grad. Stud. Univ. of Chicago, '02–'04; Ph. D. (Columbia Univ., '06); *Pullman, Wash.,* Asst. in Bot., Columbia Univ., '04–'06; Asst. Prof. of Bot., Univ. of Utah, '06–'07; Prof. of Bot., do., '07–'08; do. Washburn Coll., '08–'12; do. Univ. of Kans., '12; Prof. of Plant Physiol. and Bact., State Coll. of Wash., 1913; Dir., State Expt. Sta., State Coll. of Wash., '13—.

1908. MARK ALFRED CARLETON, B. S. (Kans. Agr. Coll., '87), M. S. (do., '93); *Washington, D. C.;* Asst. Bot., Kans. Expt. Sta., '92–'93; Cerealist, Bur. Plant Indus., U. S. D. A., '94–'12; Gen. Mgr., Penn. Chestnut Tree Blight Com., '12–'13; Cerealist, Bur. Plant Indus., U. S. D. A., '13—.

1915. WILLIAM L. CARLYLE, B. S. (Ontario Agr. Coll., '92), M. S. (Colo. Coll., '05); *Stillwater, Okla.,* in chg. Dairy School, Ontario, '93; Lect. Dairy and Live Stock, Minn. Farm Insts., '93–'97; Prof. Anim. Husb., Univ. of Wis., '97–'03; Prof. of Agr., Colo. Coll. and Dean Coll. of Agr., '04–'08; Genl. Secy. A. J. Knollin Co., Denver, Colo., '08–'10; Dir. Idaho Expt. Sta., '10–'14; Dir. Okla. Expt. Sta., '14—.

1905. LOUIS GEORGE CARPENTER, B. S. (Mich. Agr. Coll., '79), M. S. (do., '84), LL. D. (do., '07); *707 First Nat. Bank Bldg., Denver, Colo.;* Asst. Prof., Mich. Agr. Coll., '85–'88; Irr. Eng., Col. Agr. Coll. and Expt. Sta., '88–'10; Dir. Expt. Sta., do., '99–'10; State Eng., '03–'05; Consulting Irrigation Engineer, '10—.

1901. LOUIS ADELBERT CLINTON, B. S. (Mich. Agr. Coll., '89), M. S. (do., '97); *U. S. Dept. Agr., Washington, D. C.;* Asst. to Dir. Mich. Expt. Sta., '89–'93; Asst. Prof. Agr., Clemson Coll., '93–'95; Asst. Agr., Cornell Expt. Sta., '95–'02; Dir. Storrs Expt. Sta. and Prof. Agr., Conn. Agr. Coll., '02–'12; Agriculturist, Bur. Plant Indus., '12–'15; Asst. Chief, Office of Extension Work, North and West, U. S. D. A., '15—.

1910. JOHN WALDO CONNAWAY, D. V. S. (Chicago Vet. Coll., '90), M. D. (Univ. Mo., '91); *Columbia, Mo.;* Prof. Physiology, Univ. Mo., '91–'97; Vet. Expt. Sta., do., '97–'00; Prof. Compar. Med. and Vet. to Expt. Sta., Univ. Mo., '00—.

1915. THOMAS COOPER, B. S. of A. (Minn. Coll. of Agri., '08); *Fargo, N. Dak.;* Spec. Agt. Bureau of Statistics, '04–'10; Statistical Agt. and Asst., Minn. Expt. Sta., '04–'08; Asst. Agriculturist, Univ. of Minn., '08–'10; Asst. Agriculturist in chg. Farm Mgmt., '10–'11; Dir. Better Farming Assn. of N. Dak., '11–'14; Dir. Agrl. Expt. Sta. and Dir. Agrl. Ext., N. Dak. Agrl. Coll., '14—.

1910. LEE CLEVELAND CORBETT, B. S. (Cornell Univ., '90), M. S. (do., '96); *Washington, D. C.;* Asst. Hort., Cornell Univ., '91–'93; Prof. Hort. and Forestry, S. Dak. Coll., '93–'95; do., Univ. W. Va. and Expt. Sta., '95–'01; Hort., U. S. Dept. Agr., '01–'13; Asst. Chief, Bur. Plant Indus., do., '13–'14; Hort., do., '14—.

1914. ARTHUR BURTON CORDLEY, B. S. (Mich. Agr. Coll., '88), M. S. (do., '01); *Corvallis, Ore.;* grad. student, Cornell Univ., '00–'07; Asst. in Ento., Mich. Agr. Coll., '88–'90; Asst. Ento. Vt. Expt. Sta., '90–'91; Asst. Ento., U. S. D. A., '91–'93; Prof. Zool. and Ento. Expt. Sta., Ore. Agr. Coll., '95–'12; Dean, School of Agr., do., '07—; Dir. of Expt. Sta., do., '14—.

1902. CHARLES FRANCIS CURTISS, B. S. A. (Iowa State Coll., '87), M. S. A. (do., '93), D. Sc. (Mich. Agr. Coll., '07); *Ames, Iowa;* Asst. Dir. Iowa Expt. Sta., '91–'97; Prof. Agr. and Acting Dir., Iowa Expt. Sta., '97–'00; Prof. Agr. and Dir., do., '00–'02; Dean and Dir., '02—.

1911. WILLIAM HADDOCK DALRYMPLE, M. R. C. V. S. England, '86; *Baton Rouge, La.;* Prof. Vet. Sci., La. State Univ., '89—; Vet., La. Expt. Sta., '89—.

1906. EUGENE DAVENPORT, B. S. (Mich. Agr. Coll., '78), M. S. (do., '81), M. Agr. (do., '95), LL. D. (do., '07); *Urbana, Ill.;* Prof. Agr., Mich. Agr. Coll., '89–'90; Dir. Coll. of Agr., Piracicaba, Brazil, '91–'92; Dean Coll. of Agr., Univ., Ill., '95—; Dir. Agr. Expt. Sta., '96—; Dir. Agr. Ext., '14—.

1913. ROBERT JOHN H. DELOACH, A. B. (Univ. Ga., '98), A. M. (do., '06); *Experiment, Ga.;* Bot., Ga. Expt. Sta., '06–'08; Prof. Cotton Indus., Univ. Ga., '08–'13; Dir., Ga. Expt. Sta., '13—.

1911. WILLIAM RUFUS DODSON, B. S. (Univ. Mo., '90), A. B. (Harvard Univ., '94); *Baton Rouge, La.;* Asst. Biol., Univ. Mo., '90–'93; Prof. Bot., La. Univ., '94–'02; Asst. Dir., La. Expt. Stas., '02–'05; Dir., do., '05—; Dean, Coll. Agr., La. Univ., '09—.

1910. JOHN FREDERICK DUGGAR, B. S. (Miss. Agr. Coll., '87), M. S. (do., '88); *Auburn, Ala.;* Asst. in Agr., Tex. Agr. Coll., '87–'89; Asst. Dir., S. C. Expt. Sta., '90–'92; Agr. Editor Office Expt. Stas., U. S. D. A, '93–'95; Prof. Agr., Ala. Poly Inst., '96—; Dir. Ala. Expt. Sta., '03—.

1913. CLARENCE HENRY ECKLES, B. S. A. (Iowa State Coll., '95), M. S. (do., '97); *Columbia, Mo.;* Instr. and Asst. in Dairying, Iowa Coll. and Expt. Sta., '96–'01; Asst. Prof. Dairy Husb., Univ. Mo., and Dairyman Mo. Expt. Sta., '01–'06; Prof. and Dairyman, do., '06—.

1899. DAVID GRANDISON FAIRCHILD, B. S. (Kans. State Coll., '88), M. S. (do., '93); *Washington, D. C.;* Naples Zool. Sta., '93; Breslau and Berlin, '94; Bonn, '95; Buitenzorg Botanic Gardens, '96; Asst. Path. U. S. Dept. Agr., '89–'92; Special Agt. in charge Seed and Plant Production, '97–'98; Agr. Explorer, '98–'03; in charge Foreign Seed and Plant Introduction, U. S. Dept. Agr., '03—.

1880. WILLIAM GIBSON FARLOW, A. B. (Harvard Univ., '66), M. D. (do., '70), LL. D. (do., '96; Univ. Glasgow, '01; Univ. Wis., '04); *24 Quincy St., Cambridge, Mass.;* Asst. Prof. Bot., Harvard Univ., '74–'79; Prof. Cryptg. Bot., do., '79—.

1909. EDWARD HOLYOKE FARRINGTON, B. S. (Univ. Me., '81), M. S. (Yale, '82); *Madison, Wis.;* Chem., Conn. State Expt. Sta., '83–'89; do., Ill. Expt. Sta., '90–'94; Assoc. in Dairy Husb., Wis. Univ. and Expt. Sta., '94–'00; Prof. Dairy Husb., do., '00—.

1890. BERNHARD EDWARD FERNOW (Münden Forest Acad. grad., '73), LL. D. (Univ. Wis., '97; Queen's '03); *Toronto, Can.;* Chief, Div. Forestry, U. S. Dept. Agr., '86–'98; Dir. N. Y. State Coll. of Forestry, '98–'03; Lecturer Yale Forestry School, '04; Prof. of Forestry, Univ. of Toronto, '07—.

1911. MARTIN LUTHFR FISHER, B. S. (Purdue Univ., '03), M. S. (Univ. Wis., '11); *Lafayette, Ind.;* Asst. in Agr., Purdue Univ., '03–'04; Instr. Agr., do., '04–'06; Asst. Prof. Agron., do., '06–'08; Assoc. Prof. Agron., do., '08–'10; Prof. Crop Prod., do., '10—; Asst. Agr., Indiana Expt. Sta., '03–'10; Assoc. in Crops, do., '10—.

1910. ERNEST BROWNING FORBES, B. Sc. (Univ. Ill., '97), B. S. Agr. (do., '02), Ph. D. (Univ. Mo., '08); *Wooster, Ohio;* Zool. Asst., Ill. Biol. Sta., '94–'96; Asst. to State Ento. of Minn., '97–'98; Acting State Ento. Minn., '01; Asst. in Anim. Husb., Ill. Expt. Sta., '01–02; Instr. Anim. Husb., Univ. Ill., '02–'03; Asst. Prof. Anim. Husb., Univ. Mo., '03–'07; Chief in Nutr, Ohio Expt. Sta., '07—.

1908. STEPHEN ALFRED FORBES, Ph. D. (Ind. Univ., '84), LL. D. (Univ. Ill., '05), *Urbana, Ill.;* Prof. Zool., Univ. Ill., '84–'09; State Ento. Ill., '82—; Dir. Ill. State Lab. of Nat. Hist., '77—; Dean Coll. of Sci., Univ. of Ill., '88—.

1911. GEORGE STRONACH FRAPS, B. S. (N. C. Agr. Coll., '96), Ph. D. (Johns Hopkins Univ., '99); *College Station, Tex.;*

Asst. Prof. Chem., N. C. Agr. Coll., and Asst. Chem. in Expt. Sta., '99–'03; Asst. Chem., Tex. Expt. Sta., '03–'04; Assoc. Chem., do., '04–'05; Chem., do., '05—; Assoc. Prof. Chem., Tex. Agr. Coll., '03–'05; Acting Prof., do., '05–06; Assoc. Prof. Agr. Chem., do., '06—; State Chem., '06.

1888. WILLIAM FREAR, A. B. (Bucknell Univ., '81), Ph. D. (Ill. Wesleyan Univ., '83); *State College, Pa.;* Asst. Sci., Bucknell Univ., '81–'83; Asst. Chem., U. S. Dept. Agr., '83–'85; Prof. Agr. Chem.., Pa. State Coll., '85—; Vice Dir. and Chem., Pa. Expt. Sta., '87—.

1913. JONS AUGUST FRIES, B. S. (Pa. State Coll., '99), M. S. (do., '06); *State College, Pa.;* Asst. Chem., Pa. Expt. Sta., '89—'98; Expert Asst. Anim. Nutr., do., '98–'08; Asst. Dir. Inst. Anim. Nutr., '08—.

1908. BEVERLY THOMAS GALLOWAY, B. S. (Univ. Mo., '84), LL. D. (do., '02); *Ithaca, N. Y.;* Asst. Hort., Univ. Mo., '84–'87; Asst. Path., U. S. Dept. Agr., '87–'88; Path. and Chief, Div. Veg. Path. and Physiol., do., '88–'01; Chief Bur. Plant Indus., do., '01–'13; Asst. Sec. of Agr., '13–'14; Dean N. Y. State Coll. of Agr. at Cornell Univ.; Dir. Cornell Univ. Agr. Expt. Sta. and Agr. Ext., '14—.

1894. HARRISON GARMAN, D. Sc. (St. Univ. of Kentucky); *Lexington, Ky.,* First Asst. State Lab. Nat. Hist., Ill., '83–'89; Asst. Prof. Zool., Univ. Ill., '85–'89; Ento. and Bot., Ky. Expt. Sta., '89—; State Ento., Ky. '97—; Prof. of Ento. and Zool., St. Univ. of Kentucky, '11—.

1894. CHARLES CHRISTIAN GEORGESON, B. S. (Mich. Agr. Coll., '78), M. S. (do., '82); *Sitka, Alaska;* Asst. Ed. of *Rural New Yorker,* '78–'80; Prof. Agr. and Hort., Tex. Agr. Coll., '80–'83; Prof. Agr. Coll. of Agr., Imperial Univ., Tokyo, Japan, '86–'89; Prof. Agr., Kans. State Agr. Coll., '90–'97; Special Agt. U. S. Dept. Agr., Dairy Industry, Denmark, '93; Asst. Agrostologist, U. S. Dept. Agr., '97–'98; Special Agt. in charge Alaska Expt. Sta., do., '98—.

1893. CLARENCE PRESTON GILLETTE, B. S. (Mich. Agr. Coll., '84), M. S. (do., '88); *Fort Collins, Col.;* Asst. Zool., Mich. Agr. Coll., '87–'88; Ento. Iowa Expt. Sta., '88–'91; Prof. Zool. and Ento., Col. Agr. Coll. and Ento. Expt. Sta., do., '91—; Dir. Expt. Sta., do., '10—; Colo. State Ento., —.

1911. ARTHUR GOSS, B. S. (Purdue Univ., '88), M. S. (do., '95); *Lafayette, Ind.;* Asst. Chem., Ind. Expt. Sta., '88–'92; Asst., Ind. Weather Serv., '89–'92; Prof. Chem., N. Mex. Agr. Coll., and Chem. in Expt. Sta., '92–'03; Vice-Dir., N. Mex. Expt. Sta., '95–'00; Dir., Ind. Expt. Sta., '03—.

1909. HARRY SANDS GRINDLEY, B. S. (Univ. Ill., '88), Sc. D. (Har-

vard, '94); *Urbana, Ill.;* Asst. Chem., Univ. Ill., '88–'92; Asst. Chem., Harvard, '92–'93; Fellow Harvard, '93–'94; Instr. Chem., Univ. Ill., '94–'95; Asst. Prof. Chem., do., '95–'99; Assoc. Prof. Chem., do., '99–'04; Prof. and Dir. Chem. Lab., do., '04–'07; Prof. An. Chem., do., and Chief An. Chem., Expt. Sta., '07—.

1909. THEOPHILUS L. HAECKER, *University Farm, St. Paul, Minn.;* in charge Dairy Husb., Minn. Univ. and Expt. Sta., '92–'07; Prof. Dairy Husb. and Anim. Nutrition, do., '07–'09; Prof. Dairying, Anim. Husb. and Animal Nutrition, do., '10—.

1880. BYRON DAVID HALSTED, B. S. (Mich. Agr. Coll., '71), M. S. (do., '74), Sc. D. (Harvard Univ., '78); *New Brunswick, N. J.;* Ed. *American Agriculturist,* '79–'85; Prof. Bot., Iowa State Coll., '85–'89; Prof. Bot. and Hort., Rutgers Coll., '89–'10; Bot., N. J. Expt. Sta., '89—.

1902. NIELS EBBENSEN HANSEN, B. S. (Iowa State Coll., '87), M. S. (do., '95); *Brookings, S. Dak.;* Asst. Prof. Hort., Iowa State Coll., '91–'95; Prof. Hort. and Forestry, S. Dak. Agr. Coll., and Hort., Expt. Sta., '95—.

1910. JOSEPH NELSON HARPER, B. S. (Miss. Agr. Coll., '95), M. A. (Ky. Agr. Coll., '06); *Clemson College, S. C.;* Dairy Husb., Miss. Expt. Sta., '95; Dairy Husb., Ky. Expt. Sta., '96–'98; Agriculturist, do., '98–'05; Dir. and Agron., S. C. Expt. Sta., '06—.

1910. BURT LAWS HARTWELL, B. S. (Mass. Agr. Coll. and Boston Univ., '89), M. S. (Mass. Agr. Coll., '00), Ph. D. (Univ. Pa., '03); *Kingston, R. I.;* Asst. Chem., Mass. Expt. Sta., '89–'91; Asst. Chem., R. I. Expt. Sta., '91–'03; Assoc. Chem., do., '03–'07; Chem., do., '07—; Prof. Agr. Chem., R. I. State Coll., '08—; Dir., R. I. Expt. Sta., '13—.

1905. WILLET MARTIN HAYS, B. Agr. (Iowa State Coll., '85), M. Agr. (do., '86); *Kennett Sq., Pa.;* Asst. Iowa Agr. Coll., '86; Assoc. Ed., *Prairie Farmer,* '87; Asst. in Agr., Iowa Agr. Coll., '88–'89; Prof. Agr. and Agrlst., Minn. Agr. Coll. and Expt. Sta., '90-'91; do., N. Dak. Agr. Coll. and Expt. Sta., '92–'93; do., Minn. Agr. Coll. and Expt. Sta., '93–'04; Asst. Sec. of Agr., U. S. Dept. Agr., '04–'13; Farmer, '15—.

1911. HARRY HAYWARD, B. S. (Cornell Univ., '94), M. S. (do., '01); *Newark, Del.;* Asst. Prof. Dairy Husb., Pa. State Coll., '97–'02; Assoc. Prof. An. and Dairy Husb., N. H. Agr. Coll., '02–'03; Asst. Chief Dairy Div., U. S. Dept. Agr., '03; Dir. Agr. Dept., Mount Hermon School, '03–'06; Dean Agr. Dept., Del. Coll., and Dir. Del. Expt. Sta., '06—; Dir. Agrl. Ext. '14—.

1909. WILLIAM PARKER HEADDEN, A. B. (Dickinson, '72), A. M.

(do., '75), Ph. D. (Univ. Giessen, '74); *Fort Collins, Col.;* Asst., Univ. Pa., '74–'76; Prof. Chem., Md. Agr. Coll., '80–'84; do., Univ. Denver, '84–'89; do., S. Dak. School of Mines, '89–'91; Dean, do., '92–'93; Prof. Chem. and Geol., Col. Agr. Coll., and Chem., Expt. Sta., '93—.

1909. ULYSSES PRENTISS HEDRICK, B. S. (Mich. Agr. Coll., '93), M. S. (do., '95); *Geneva, N. Y.;* Asst. Hort., Mich. Agr. Coll., '93–'95; Prof. Bot. and Hort., Ore. Agr. Coll., and Hort., Expt. Sta., '95–'97; Prof. Bot. and Hort., and Hort., Expt. Sta., Utah, '97–'99; Prof. Hort., Mich. Agr. Coll., '99–'05; Hort., N. Y. Expt. Sta., '05—.

1905. JOSEPH LAWRENCE HILLS, B. S. (Mass. Agr. Coll. and Boston Univ., '81), D. Sc. (honorary, '03, Rutgers Coll.); *Burlington, Vt.;* Asst. Chem., Mass. Expt. Sta., '82–'83; Asst. Chem., N. J. Expt. Sta., '84–'85; Chem. Phos. Mining Co., Ltd., Beaufort, S. C., '85–'88; Chem., Vt. Expt. Sta., '88–'98; Dir., do., '98—; Prof. Agr. Chem., Univ. Vt., '93—; Dean, Dept. Agr., do., '98—.

1889. LELAND OSSIAN HOWARD, B. S. (Cornell Univ., '77), M. S. (do., '86), Ph. D. (Georgetown Univ., '96); *Washington, D. C.;* Asst. Ento., U. S. Dept. Agr., '78–'94; Chief Ento., do., '94—; Perm. Sec., A. A. A. S., '98—.

1912. WALTER LAFAYETTE HOWARD, B. Agr., B. S. (Univ. Mo., '01), M. S. (do., '03), Ph. D. (Univ. Halle-Wittenberg, '06); *University Farm, Davis, Calif.;* Asst. in Hort., Univ. Mo., '01–'03; Instr., do., '03–'04; Asst. Prof., do., '05–'08; Sec., Mo. State Board Hort., '08–'12; Prof. Hort., Univ. Mo., '08–'15; Assoc. Prof. Pomology, Univ. of Calif., '15—.

1903. THOMAS FORSYTH HUNT, B. S. (Univ. Ill., '84), M. S. (do., '92), D. Agr. (do., '04), D. Sc. (Mich. Agr. Coll., '07); *Berkeley, Cal.;* Asst. State Ento. of Ill., '85–'86; Asst. Agr., Univ. Ill., '86–'88; Asst. Agr., Ill. Expt. Sta., '88–'91; Prof. Agr., Pa. State Coll., '91–'92; Prof. Agr., Ohio State Univ., '92–'95; Dean Coll. Agr., Ohio State Univ., '95–'03; Prof. Agron., Cornell Univ., and Agron., Expt. Sta., '03–'06; Dean Coll. Agr., and Dir. Agr. Expt. Sta., Pa. State Coll., '06–'12; Dean Coll. Agr., Univ. Cal., and Dir. Expt. Sta., '12—.

1908. WILLIAM DANIEL HURD, B. S. (Mich. Agr. Coll., '99), M. Agr. (do., '08); *Amherst, Mass.;* Instr., Lansing High School, '99–'01; Prof. Hort., Briarcliff Agr. School, '01–'03; Prof. Agri., Univ. Me., '03–'05; Acting Dean, Coll. of Agr., do., '05–'06; Dean, '06–'09; Dir. Agr. Ext., '09—.

1898. HENRY CLAY IRISH, B. S. (S. Dak. Agr. Coll., '91), M. S. (Iowa State Coll., '98); *Missouri Botanical Garden, St.*

Louis, Mo.; Hort. Asst., Mo. Bot. Gard., '95–'02; Supt., do., '03–'12; Landscape Architect, '12–'13; Asst. Prof., Landscape Gard. and Flor., Iowa St. Coll., '13–'14; Supervisor, School Gardens, St. Louis, '14—.

1908. Myer Edward Jaffa, Ph. B. (Univ. Cal., '77), M. S. (do., '96); *Berkeley, Cal.;* Asst. Chem., U. S. Census, '79–'80; Asst. Agr. Dept., Univ. Cal., '80–'81; Asst. Chem., Northern Transcontinental Surv., '81–'83; Asst. Chem., Univ. Cal., '83–'96; Asst. Prof. Agr., do., '96–'06; do., Nutr., '06–'08; Prof. Nutr., do., '08—.

1885. Edward Hopkins Jenkins, A. B. (Yale Univ., '72), Ph. D. (do., '79); *New Haven, Conn.;* Chem., Conn. Expt. Sta., '76–'00; Vice Dir., do., '82–'00; Dir., do., '00—; Treas., do., '01—; Dir., Storrs Expt. Sta., '12—.

1915. J. Shirley Jones, B. S. (Univ. of Calif., '03); M. S. (Cornell Univ., '14); *Moscow, Idaho;* Asst. in Chem., Univ. of Calif., '02–'03; Asst. Chem. to Dr. H. E. Miller, San Francisco, '03–'04; Chem. for Giant Powder Co., San Jose, Calif., '05–'07; Chem. Idaho Expt. Sta. and Prof. Agrl. Chem., Idaho St. Coll. of Agr., '07–'14; Dir. Idaho Expt. Sta., '14—.

1894. Whitman Howard Jordan, B. S. (Univ. Me., '75), M. S. (do., '79), D. Sc. (do., '96), LL. D. (Mich. Agr. Coll., '07); *Geneva, N. Y.;* Asst. Chem., Conn. Expt. Sta., '78–'79; Instr. Agr., Univ. Me., '79–'80; Prof. Agr. and Agr. Chem., Pa. State Coll., '81–'85; Dir., Me. Expt. Sta., '85–'96; Prof. Agr., Univ. Me., '94–'96; Dir., N. Y. Expt. Sta., '96—.

1915. Joseph Hoeing Kastle, B. S. (State Coll. of Kentucky, '84); M. S. (do., '06); Ph. D. (Johns Hopkins Univ., '88), *Lexington, Ky.;* Scholar in Chem. State Coll. of Ky., '85–'86; Lect. Asst. Chem., do., '86–'87; Fellow in Chem., do., '87–'88; Prof. of Chem., do., '88–'05; Chief, Div. Chem. Hygienic Lab., U. S. Public Health & Marine Hosp. Serv., '05–'09; Head Prof. of Chem., Univ. of Va., '09–'11; Research Prof. of Chem., Ky. Agrl. Expt. Sta., '11–'12; Dir., do., and Dean Coll. of Agr., State Univ. Ky., '12—.

1912. John Chester Kendall, B. S. (N. H. Coll., '02); *Durham, N. H.;* Instr. in Dairy Husb., N. C. Agr. Coll., '02–'03; Asst. Prof. of Dairy Husb., do., '03–'06; State Dairy Comr., Kans., '06–'07; Prof. of Dairy Husb., Kans. Agr. Coll., '08–'10; Dir., N. H. Expt. Sta., '10—; Dir. Agr. Ext., '11—.

1909. Benjamin Wesley Kilgore, B. S. (Miss. Agr. Coll., '88), M. S. (do., '90); *Raleigh, N. C.;* Asst. Chem., Miss. Agr. Coll., '88–'89; do., N. C. Expt. Sta., '89–'97; Prof. Chem., Miss. Agr. Coll. and Agr. Expt. Sta., '97–'99; State Chem., N. C., '99—; Dir., N. C. Expt. Sta., '01–'07; do., '13—.

1911. Henry Granger Knight, A. B. (Univ. Wash., Seattle, '02), A. M. (do., '04); *Laramie, Wyo.;* Asst. Chem., Univ. Wash., '00–'01; Instr., do., '01–'02; Asst. Chem., Univ. Chicago, '02–'03; Asst. Prof. Chem., Univ. Wash., '03–'04; Prof. Chem., Univ. Wyo., and State Chem., '04—; Dir., Wyo. Expt. Sta., '10—.

1889. Edin Fremont Ladd, B. Sc. (Univ. Me., '84); *Agricultural College, N. Dak.;* Asst. Chem., N. Y. State Expt. Sta., '84–'87; Chief Chem., do., '87–'90; Prof. Chem., N. Dak. Agr. Coll. and Chem. Expt. Sta., '90—; Food Comr. and State Chem., N. Dak., '00—.

1883. William Rane Lazenby, B. Agr. (Cornell Univ., '74), M. Agr. (Iowa Agr. Coll., '87); *Columbus, Ohio;* Instr. Hort., Cornell Univ., '74–'77; Asst. Prof. Hort., do., '77–'81; Prof. Hort. and Bot., Ohio State Univ., '81–'82; Dir., Ohio Expt. Sta., '82–'87; Prof. Hort. and Forestry, Ohio State Univ., '82–'09; Prof. Forestry, do., '09—.

1899. Joseph Bridgeo Lindsey, B. Sc. (Mass. Agr. Coll., '83), Ph. D. (Univ. Göttingen, '92); *Amherst, Mass.;* Asst. Chem., Mass. State Expt. Sta., '83–'85; Commercial Chem., '85–'89; Assoc. Chem., Mass. State Expt. Sta., '92–'95; Head Dept. Foods and Feeding, Hatch Expt. Sta., '95–'07; Chem., Mass. Expt. Sta., '07—; Vice Dir., do., '09—; Head Dept. Chem., Mass. Agr. Coll. and Goessmann Prof. of Agr. Chem., '11—.

1911. Frederick Bloomfield Linfield, B. S. A. (Ontario Agr. Coll., '91); *Bozeman, Mont.;* Asst. in Dairying, Ontario Agr. Coll., '92–'93; Prof. Anim. Indus. and Dairying, Utah Agr. Coll., '93–'02; Prof. Agr., Mont. Agr. Coll. '02—; Acting Dir., Mont. Expt. Sta., '03; Dir., do., '04—.

1912. Charles Bernard Lipman, B. Sc. (Rutgers Coll., '04), M. Sc. (do., '09), M. S. (Univ. Wis., '09), Ph. D. (Univ. Cal., '10); *Berkeley, Cal.;* Instr. in Soil Bact., Univ. Cal., '09–'10; Asst. Prof. Soils, do., '10–'12; Assoc. Prof. of Soils, do., and Soil Chem. and Bact., Cal. Expt. Sta., '12—.

1909. Jacob G. Lipman, B. Sc. (Rutgers, '98), A. M. (Cornell, '00), Ph. D. (do., '03); *New Brunswick, N. J.;* Asst. Chem., N. J. Expt. Sta., '98–'99; Fellow Chem., Cornell, '01; Soil Chem. and Bact., N. J. Expt. Sta., '01—; Asst. Prof. Agr., Rutgers, '06–'07; Assoc., do., '07–'10; Prof. Soil Chem. and Bact., '10—; Dir., N. J. Expt. Stas., '11—.

1911. Edward Read Lloyd, B. S. (Ala. Poly. Inst., '87), M. S. (do., '88); *Agricultural College, Miss.;* Prof. Agr., Miss. Agr. Coll., '00–'05; Dir. Farmers' Insts., do., '06–'10; Vice Dir. and Anim. Husb., Miss Expt. Sta., '10–'12; Dir., do., '12; Dir. Agr. Ext., '14—.

1911. Charles Alfred Lory, B. Ped. (State Normal School, Greeley, Col., '98), B. S. (Univ. Col., '01), M. S. (do., '02), LL. D. (do., '09); *Fort Collins, Col.;* Asst. in Physics, Univ. Col., '99–'02; Prin. Cripple Creek High School, '02–'04; Acting Prof. Physics, Univ. Col., '04–'05; Prof. Physics and Elect. Engin., Col. Agr. Coll., '07–'09; Pres., do., '09—.

1899. Robert Hills Loughridge, B. S. (Univ. Wis., '71), Ph. D. (do., '76); *Berkeley, Cal.;* Asst. Prof. Chem., Univ. Miss., '72–'74; Asst. State Geol., Miss., '72–'74; do., Ga., '74–'78; do., Ky., '82–'85; Prof. Agr. Chem., S. C. Coll., '85–'90; Asst. Prof. Agr. Chem. and Geol., Univ. Cal., '91–'08; Assoc. Prof., do., '08–'09; Emeritus Prof. Agr. Chem., do., '09—.

1901. Thomas Lyttleton Lyon, B. S. A. (Cornell Univ., '91), Ph. D. (Göttingen, '94); *Ithaca, N. Y.;* Instr. Chem., Univ. Nebr., '91–'93; Asst. Chem., Nebr. Expt. Sta., '94–'95; Assoc. Prof. Agr., Univ. Nebr., '95–'99; Prof. Agr., do., and Assoc. Dir. Expt. Sta., '99–'06; Prof. Expt. Agron., Cornell Univ. and Expt. Sta., '06—.

1911. Arthur Gillett McCall, B. S. Agr. (Ohio State Univ., '00); *Columbus, Ohio;* Asst., Bur. Soils, U. S. Dept. Agr., '00–'04; Asst. Prof. Agron., Ohio State Univ., '04–'05; Assoc. Prof. Agron., do., '05–06; Prof. Agron., do., '06—.

1911. Charles Edward Marshall, Ph. B. (Univ. Mich., '95), Ph. D. (do., '02); *Amherst, Mass.;* Asst. Bact., Univ. Mich., '93–'96; do., Mich. Expt. Sta., '96–'98; Bct. and Hygienist, do., '98–'12; Sci. and Vice Dir., do., '08–'12; Prof. Bact. and Hyg., Mich. Agr. Coll., '03–'12; Dir. Graduate School and Prof. of Microbiol., Mass. Agr. Coll., '12—.

1911. Frederick Rupert Marshall, B. S. Agr. (Ontario Agr. Coll., '99), B. S. A. (Iowa State Coll., '00); *Washington, D. C.;* Asst. Prof. Anim. Husb., Iowa State Coll., '01–'03; Prof. Anim. Husb., Tex. Agr. Coll., '03–'07; Prof. Anim. Husb., Ohio State Univ., '07–'12; Prof. Anim. Indus., Univ. Cal., and Anim. Husb., Cal. Expt. Sta., '12–'13; Senior Anim. Husb., Bur. Anim. Indus., U. S. D. A., '13—.

1911. David William May, B. Agr. (Univ. Mo., '94), M. Agr. (do., '96); *Mayaguez, P. R.;* Asst. Agr., Missouri Expt. Sta., '97; Sci. Asst. Office Expt. Stas., U. S. D. A., '00–'02; Anim. Husb., Ky. Expt. Sta., '02–'04; Special Agt. in charge, P. R. Expt. Sta., '04—.

1905. Lucius Herbert Merrill, B. S. (Univ. Me., '83), D. Sc. (honorary, do., '08); *Orono, Me.;* Chem., Me. Expt. Sta.,

'86–'08; Prof. Biol. Chem., Univ. Me., '98–'07; Prof. Biol. and Agr. Chem., do., '07—.

1909. MERRITT FINLEY MILLER, B. S. Agr. (Ohio State Univ., '00), M. S. A. (Cornell Univ., '01); *Columbia, Mo.;* Asst. Bur. Soils, U. S. Dept. Agr., '01–'02; Instr. Agron., Ohio State Univ., '02–'03; Asst. Prof., do., '03–'04; Prof. Agron., and Agron., Univ. Mo. and Expt. Sta., '04—.

1900. JOHN HARCOURT ALEXANDER MORGAN, B. S. A. (Univ. Toronto, '89); *Knoxville, Tenn.;* Prof. Ento. and Hort., La. State Univ., '89–'93; Prof. Zool. and Ento., do., '93–'04; Ento., La. Expt. Stas., '89–'04; Dir. Gulf Biol. Sta., '99–'05; Dir. Tenn. Expt. Sta., '05—.

1911. FRED WINSLOW MORSE, B. S. (Worcester, '87), M. S. (do., '00); *Amherst, Mass.;* Asst. Chem., Mass. Expt. Sta., '87–'88; do., N. H. Expt. Sta., '88–'89; Chem., do., '89–'09; Vice Dir. do., '96–'09; Prof. Chem., N. H. Agr. Coll., '90–'09; Research Chem., Mass. Expt. Sta., '10—.

1912. WARNER JACKSON MORSE, B. S. (Univ. Vt., '98), M. S. (do., '03), Ph. D. (Univ. Wis., '12); *Orono, Me.;* Teach Nat. Sci., Montpelier Seminary, '99–'01; Asst. Bot., Vt. Expt. Sta., '01–'06; Instr. Bot., do., '01–'05; Asst. Prof. Bact., do., '05–'06; Plant Path, Me. Expt. Sta., '06—.

1909. FREDERICK BLACKMAR MUMFORD, B. S. (Mich. Agr. Coll., '91), M. S. (do., '93); *Columbia, Mo.;* Asst. Mich. Expt. Sta., '91–'95; Asst. Prof. Agr., Mich. Agr. Coll., '93–'95; Prof. Agr., Univ. Mo., '95–'04; Acting Dean Coll. Agr., Univ. Mo., aud Acting Dir., Mo. Expt. Sta., '03–'05; Prof. Anim. Husb., Univ. Mo., '04—; in charge Anim. Husb. Dept., Mo. Expt. Sta., '06—; Dean Agr. and Dir. Expt. Sta., '09—.

1901. HERBEBT WINDSOR MUMFORD, B. S. (Mich. Agr. Coll., '91); *Urbana, Ill.;* Instr., Mich. Agr. Coll., and Asst., Expt. Sta., '95–'96; Asst. Prof. Agr. and Anim. Husb., do., '96–'99; Prof. Agr., do., '99–'01; Prof. Anim. Husb., Univ. Ill., and Chief in Anim. Husb., Ill. Expt. Sta., '01—.

1913. MARTIN NELSON, B. S. A. (Univ. Wis., '05), M. S. (do., '06); *Fayetteville, Ark.;* Adj. Prof. Field Crops and Soils Univ. Nebr. and Expt. Sta., '06–'07; Asst. Prof., do., '07–'08; Prof Agron. and Agron., Univ. Ark. and Expt. Sta., '08–'13; Dean Univ. Ark. and Dir. Expt. Sta., '13—.

1893. HERBERT OSBORN, B. S. (Iowa State Coll., '79), M. S. (do., '80); *Columbus, Ohio;* Asst. Zool. and Ento., Iowa State Coll., '79–'83; Asst. Prof., do., '83–'85; Prof., do., '85–'98; Prof. Zool. and Ento., Ohio State Univ., '98—.

1893. LOUIS HERMAN PAMMEL, B. Agr. (Univ. Wis., '85), M. S.

(do., '89), Ph. D. (Wash. Univ., '99); *Ames, Iowa;* Asst., Shaw School of Bot., '86–'89; Tex. Agr. Expt. Sta., '89; Prof. Bot., Iowa State Coll., '89—; Bot., Iowa Expt. Sta., '92—.

1893. Henry Jacob Patterson, B. S. (Pa. State Coll., '86); *College Park, Md.;* Asst. Chem., Pa. Expt. Sta., '86–'88; Chem., Md. Expt. Sta., '88–'98; Dir. and Chem., do., '98; Pres. Md. Agr. Coll., '13—.

1910. Raymond Pearl, A. B. (Dartmouth Coll., '99), Ph. D. (Univ. Mich., '02); *Orono, Me.;* Asst. Zool., Univ. Mich., '99–'02; Instr. Zool., do., '02–'06; Instr. Zool., Univ. Penn., '06–'07; Biol. and Head Dept. Biol., Me. Expt. Sta., '07—; Assoc. Ed. *Zool. Jahresber*, '06–'08; *Biometrika,* '06–'10; *Zentbl. Allg. u. Expt. Biol.,* '10—.

1909. Raymond Allen Pearson, B. S. A. (Cornell Univ., '94), M. S. A. (do., '99); *Ames, Iowa;* Asst. Chief Dairy Div., U. S. Dept. Agr., '95–'02; Mgr. Walker-Gordon Lab. Co., N. Y. and Phila., '02–'03; Prof. Dairy Ind., Cornell Univ., '03–'07; N. Y. Comr. Agr., '07–'12; Pres. Iowa State Coll., '12—.

1910. William Robert Perkins, B. S. (Miss. Agr. Coll., '91); M. S. (do., '94); *Baton Rouge, La.;* Asst. State Chem., Miss., '91–'94; Chem., Miss. Expt. Sta., '94–'06; Asst. Prof. Agr., Miss. Agr. Coll., '06; Agron., Miss. Expt. Sta., '07–'10; Dir. Agr. Dept., and Prof. Agron., Clemson Coll., '10–'11; Supt. Syndicate Farm, Deeson, Miss., '11—.

1909. Charles Vancouver Piper, B. S. (Univ. Wash., '85), M. S. (do., '92; Harvard, '00); *Washington, D. C.;* Prof. Ento., Wash. State Coll., '92–'93; Prof. Bot. and Zool., do., and Bot. and Ento., Expt. Sta., '93–'03; Syst. Agrostologist, U. S. Dept. Agr., '03–'04; Agrostologist, do., '05—.

1890. Charles Sumner Plumb, B. S. (Mass. Agr. Coll., '82); *Columbus, Ohio;* Asst. Ed. *Rural New Yorker,* '83–'84; First Asst., N. Y. Expt. Sta., '84–'87; Prof. Agr., Univ. Tenn., and Asst. Dir., Expt. Sta., '87–'90; Prof. Agr. Sci., Purdue Univ., '90–'94; Prof. Anim. Indus. and Dairying, do., '94–'00; Prof. Anim. Indus., do., '00–'02; Vice Dir., Ind. Expt. Sta., '90–'91; Dir., do., '91–'02; Prof. Anim. Indus., Ohio State Univ., '02—.

1894. Frank William Rane, B. Agr. (Ohio State Univ., '91), M. Sc. (Cornell Univ., '92); *State House, Boston, Mass.;* Hort. and Microscopist, W. Va. Expt. Sta., '92–'95; Prof. Agr. and Hort., W. Va. Univ., '93–'95; Prof. Agr. and Hort., N. H. Coll., '95–'98; Prof. Hort., do., '98–'00; Prof. Foresty and Hort., do., '00–'06; State Forester, Mass., '06—.

1913. James Burness Rather, B. S. (Tex. Agr. Coll., '07), M. S. (do., '11), A. M. (Johns Hopkins Univ., '15); *Fayetteville, Ark.;* Asst. State Chem. Tex., '07–'09; Asst. Chem. Tex. Expt. Sta., '08–'12; First Asst. Chem., do., '12–'14; Prof. of Agr. Chem. and Chem. to Expt. Sta., Coll. of Agr., Univ. of Ark., '15—.

1913. George Matthew Reed, A. B. (Geneva Coll., '00), A. M. (Univ. Wis., '04), Ph. D. (do., '07); *Columbia, Mo.;* Prof. Nat. Sci., Amity Coll., '00–'03; Asst. in Bot., Univ. Wis., '04–'07; Instr. in Bot., do., '07; Asst. Prof. Bot., Univ. Mo., '07–'12; Prof. Bot., do., '12—; Bot. Mo. Expt. Sta., '09—.

1881. Isaac Phillips Roberts, M. Agr. (Iowa State Coll., '75); 731 Cameron Avenue, *Fresno, Cal.;* Prof. Agr. and Dean Agr., Cornell Univ., '73–'94; Dir. Cornell Expt. Sta., '88–'03; Dir. Col. Agr., '94–'03; Prof. Emeritus, lecturer and author, '03—.

1893. James Wilson Robertson, LL. D. (Toronto Univ., and Queen's Univ., '03; Univ. New Brunswick, '04); *Box 510, Ottawa, Can.;* Prof. Dairying, Ontario Agr. Coll., '86–'90; Dairy Comr. Canada, '90–'95; Comr. Agr. and Dairying, '95–'04; Prin., MacDonald Coll., '05–'09; Chairman Royal Com. on Indus. Training and Tech. Ed., '10—.

1909. Peter Henry Rolfs, B. S., M. S. (Iowa State Coll., '91); *Gainesville, Fla.;* Asst. Bot., Iowa State Coll., '91; Ento. and Bot., Fla. Expt. Sta., '92–'98; Bot. and Hort., do., '98–'99; Bot. and Bact., S. C. Expt. Sta., '99–'01; Plant Path. in charge Sub-Trop. Lab., U. S. Dept. Agr., Miami, Fla., '01–'06; Dir., Fla. Expt. Sta., '06—; State Supt. Farmers' Institutes, '07—.

1911. George McCullough Rommel, B. S. (Iowa Wesleyan Univ., '97), B. S. A. (Iowa State Coll., '99); *Washington, D. C.;* Expert in Anim. Husb., Bur. Anim. Indus., U. S. Dept. Agr., '01–'05; Anim. Husb., do., '05–'09; Chief, Anim. Husb. Div., do., '10—

1909. Harry Luman Russell, B. S. (Univ. Wis., '88), M. S. (do., '90), Ph. D. (Johns Hopkins, '92); *Madison, Wis.;* Fellow Univ. Wis., '88–'90; Fellow Univ. Chicago, '92–'93; Asst. Prof. Bact., Univ. Wis., '93–'96; Prof. do., '96–'97; Bact., Wis. Expt. Sta., '93–'97; Dir. State Hygienic Lab., '03–'07; Dean Coll. of Agr. and Dir. Expt. Sta., Univ. Wis., '07—; Dir., Agr. Ext., '14—.

1912. Walter George Sackett, B. S. (Univ. Chicago, '02); *Fort Collins, Col.;* Prof. Nat. Sci., Meredith Coll., '02–'04; Special Agt., U. S. Dept. Agr., '04: Instr. Bact. and Hyg.,

Mich. Agr. Coll., '04–'06; Asst. Prof. and Hyg., do., and Asst. Bact. Mich. Expt. Sta., '06–'08; Bact., Col. Expt. Sta., '08—.

1908. EZRA DWIGHT SANDERSON, B. S. (Mich. Agr. Coll., '97), B. S. Agr. (Cornell, '98); *Chicago, Ill.;* Asst. State Ento. Md., '98–'99; Ento., Del. Expt. Sta., and Assoc. Prof. Zool., Del. Coll., '99–'02; State Ento. Tex., and Prof. Ento., Tex. A. and M. Coll., '02–'04; Ento., N. H. Expt. Sta., and Prof. Ento., and Zool. N. H. Coll., '04–'09; Dir. N. H. Expt. Sta., '07–'09; Dean Coll. Agr., W. Va. Univ., '10–'15; Dir., W. Va. Expt. Sta., '12–'15; Student, Univ. Chi., '15—.

1910. ROBERT SIDNEY SHAW, B. S. (Ontario Agr. Coll., '93); *East Lansing, Mich.;* Asst. Agr., Mont. Agr. Coll. and Expt. Sta., '97–'02; Prof. Agr., Mich. Agr. Coll., '02–'08; Dean Agr., do., and Dir. Expt. Sta., '08—.

1893. THOMAS SHAW, *2135 Knapp Street, St. Paul, Minn.;* Prof. Agr., Ontario Agr. Coll., '88–'93; Prof. Anim. Husb., Minn. Coll. Agr., '93–'03; Ed. *Farmer,* '03–'08; Northwest Ed. Orange Judd Publications, '08—.

1898. JOHN HENRY SHEPPERD, B. Agr. (Iowa State Coll., '91), M. S. A. (Univ. Wis., '93); *Agricultural College, N. Dak.;* Ed. Staff *Orange Judd Farmer,* '93; Prof. Agr., N. Dak. Agr. Coll., and Agriculturist Expt. Sta., '93–'04; Dean and Vice Dir., '04—.

1909. JOHN HARRISON SKINNER, B. S. (Purdue Univ., '97); *Lafayette, Ind.;* Asst. Agr., Ind. Expt. Sta., '99–'01; Instr. Anim. Husb., Univ. Ill., '01–'02; Assoc. Prof. Anim. Husb., Purdue Univ., '02–'06; Prof., do., '06; Dean Agr. Dept., Purdue Univ., '07—.

1907. CLINTON DEWITT SMITH, M. S. (Cornell Univ., '75); *Trumansburg, N. Y.;* Dir. Ark. Expt. Sta., '90; Dir. Minn. Sta., and Prof. Dairy Husb., Univ. Minn., '90–'93; Dir. Mich. Expt. Sta. and Prof. Agr., '93–'08; Dir. and Dean Spec. Course, Mich. Agr. Coll., '99–'08; Dir. Escola Agricola Practica, Brazil, '08–'12; Farmer and Lecturer, '12—.

1907. HOWARD REMUS SMITH, B. Sc. (Mich. Agr. Coll., '95); *University Farm, St. Paul, Minn.;* Teach, Tilford Collegiate Acad. and Rock Island High School, '95–'09; Acting Prof. Agr., Univ. Mo., '00–'01; Asst. Prof. Anim. Husb., Univ. Nebr., '01; Assoc. Prof., do., '02; Prof., do., '03–'12; Anim. Husb., Univ. Minn., '12–'14.

1899. HARRY SNYDER, B. S. (Cornell Univ., '89); *1800 Summit Ave., Minneapolis, Minn.;* Asst. Chem., Cornell Univ. Expt. Sta., '90–'91; Asst. Instr. Qual. Anal., do., '89–'90; Prof.

Agr. Chem., Univ. Minn., and Chem., Expt. Sta., '91–'09; Chem., Russell Miller Milling Co., '09—.

1909. ANDREW MCNAIRN SOULE, B. S. (Univ. Toronto, '93), Sc. D. (honorary, Univ. Ga., 10); *Athens, Ga.;* Asst. Dir., Mo. Expt. Sta., '94; Asst. Prof. Agr. and Asst. Agriculturist, Tex. Agr. Coll. and Expt. Sta., '94–'99; Dir. Tenn. Expt. Sta. and Chairman Agr. Faculty, Univ. Tenn., '99–'04; Dean of Agr. and Dir. Expt. Sta., Va. Poly. Inst., '04–'07; Pres. Coll. Agr. Univ. Ga., '07—.

1903. WILLIAM JASPER SPILLMAN, B. S. (Univ. Mo., '86), M. S. (do., '89), Sc. D. (do., '10); *Washington, D. C.;* Prof. Sci., Mo. State Normal, '87–'89; Prof. Sci., Vincennes Univ., '89–'91; Prof. Sci., Ore. State Normal, '91–'94; Prof. Agr., State Coll. Wash., '94–'01; Agrostologist, U. S. Dept. Agr., '01–'04; Agriculturist in charge Farm Management, do., '04—.

1911. FRANK LINCOLN STEVENS, B. L. (Hobart, '91), B. S. (Rutgers Coll., '93), M. S. (do., '97); Ph. D. (Univ. Chicago, '00), *Urbana, Ill.;* Teacher of Sci. Racine Coll., '93–'94; do., Columbus, O., High School, '94–'97; Instr. in Biol., N. C. Agr. Coll., '00–'02; Prof. Bt. and Veg. Path., do., '03–'11; Biol., N. C. Expt. Sta., '03–'11; Dean, P. R. Coll. Agr., '12–'14; Prof. Plant Path., Univ. Ill., '14—.

1908. WILLIAM ALTON TAYLOR, B. S. (Mich. Agr. Coll., '88), D. Sc. (do., '13); *Washington, D. C.;* Asst. Pomol., U. S. Dept. Agr., '91–'01; Pomol. in charge Field Investigations, '01–'10; Asst. Chief, Bur. Plant Indus., '11–'13; Chief, do., '13—.

1911. ROSCOE WILFRED THATCHER, B. Sc. (Univ. Nebr., '98), M. A. (do., '01); *University Farm, St. Paul, Minn.;* Asst. Chem., Nebr. Expt. Sta., '99–'01; Asst. Chem., Wash. Expt. Sta., '01–'03; Chem., do., '03–'12; Asst. Prof. Chem., State Coll. Wash., '04–'06; Assoc. Prof., do., '06–'10; Prof. Agr. Chem. and Head of Dept. Agr., do., '10–'13; Dir. Wash. Expt. Sta., '07–'13; Prof. Agr. Chem. and Agr. Chem., Univ. Minn. and Expt. Sta., '13—.

1907. CHARLES EMBREE THORNE, M. Agr. (Ohio State Univ., '90); *Wooster, Ohio;* Dir. Ohio Expt. Sta., '87—.

1910. EDWARD GAIGE TITUS, B. S. (Col. Agr. Coll., '99); M. S. (do., '01), D. Sc. (Harvard, '11); *Logan, Utah;* Asst. Dept. Zool. and Ento., Col. Agr. Coll., '00–'01; Field Asst. State Ento., Ill., '01–'03; Spec. Agt., Bur. Ento., U. S. Dept. Agr., '03–'07; Prof. Zool. and Ento., Utah Agr. Coll. and Ento., Expt. Sta., '07—.

1901. CHARLES ORRIN TOWNSEND, B. S. (Univ. Mich., '88), M. S. (do., '91), Ph. D. (Leipsic, '97); *Washington, D. C.;* Prof.

St. Johns Coll., Md.; '88–'91; Prof. Sci., Wesleyan Coll., Ga., '91–'95; Instr. Bot., Barnard Coll., '98; Prof. Bot., Md. Agr. Coll., and State Plant Path. Md., '98–'01; Path. Bur. Plant Indus., U. S. Dept. Agr., '01–'10; do., '12—; Consulting Agr., U. S. Sugar and Land Co., '10–'12.

1881. SAMUEL MILLS TRACY, B. A. (Mich. Agr. Coll., '68), M. S. (do., '76); *Biloxi, Miss.;* Asst. Prof. Agr, Mo. State Univ., '77–'80; Prof. Bot. and Hort., do., '80–'87; Dir. Miss. Expt. Sta., '87–'97; Spec. Agt. U. S. Dept. Agr., '97—.

1894. WILLIAM TRÉLEASE, B. S. (Cornell, '80), D. Sc. (Harvard), '84), LL. D. (Wis., '02; Mo., '03; Wash. Univ., '07); *Urbana, Ill.;* Prof. Bot., Univ. Wis., '83–'85; Engelmann Prof. Bot. and Dir. Shaw School Bot., Wash. Univ., '85—; Dir. Mo. Bot. Gard., '89–'12; Research Work, '12–'13. Prof. Bot., Univ. Ill., '13—.

1913. PERRY FOX TROWBRIDGE, B. Pd. (Mich. Norm. Coll., '92), Ph. B. (Univ. Mich., '92), A. M. (do., '05), Ph. D. (Univ. Ill., '06), M. Pd. (Mich. Norm. Coll., '11); *Columbia, Mo.;* Instr. Chem., Univ. Mich., '94–'02; Sugar Chem., do.. '02–'05; Research Asst. and Instr. in Chem., Univ. Ill., '05–'07; Agr. Chem. and Assoc. Chem., Univ. Mo. and Expt. Sta., '07–'08; Prof. and Chem., do., '08—.

1907. ALFRED CHARLES TRUE, B. A. (Wesleyan Univ., Conn., '73), M. A. (do., '76), Ph. D. (Erskine Coll., S. C., '86), D. Sc. (Wesleyan Univ., '06); *Washington, D. C.;* Prin. High School, Essex, N. Y., '73–'75; Instr. State Normal School, Westfield, Mass., '75–'82; Grad. Stud., Harvard Univ., '82–'84; Instr., Wesleyan Univ., '84–'88; Ed., U. S. Office Ext. Stas., '88–'91; Asst. Dir., do., '91–'93; Dir., do., '93–'14; Dir., States Relations Service, U. S. D. A., '14—.

1914. HUBERT EVERETT VAN NORMAN, B. S. (Mich. Agr. Coll., '97); *Davis, Calif.;* Mgr. Dairy Farm, '97–'98; Supt. Univ. Farm, Purdue Univ., '98–'02; Chief, Dairy Dept., Purdue Univ., '02–'05; Prof. Dairy Husb., Pa. St. Coll., '05–'13; Prof. Dairy Mgmt., Univ. of Calif., '13—; Vice Dir., Agr. Expt. Sta. and Dean, Univ. Farm School, '13—.

1908. ALFRED VIVIAN, Ph. G. (Univ. Wis., '94); *Columbus, Ohio;* Instr. Phar., Univ. Wis., '94–'95; Asst. Agr. Chem., do., '95–'97; Instr., do., and Asst. Chem., Expt. Sta., '97–'02; Assoc. Prof. Agr. Chem., Ohio State Univ., '02–'05; Prof. Agr. Chem., do., '05—.

1912. JOHN FRANCIS VOORHEES, B. S. A. (Univ. Tenn., '09), M. S. A. (do., '11), *Knoxville, Tenn.;* Asst. Observ., U. S. Weather Bur., New Orleans, La., '01; do., Knoxville.

Tenn., '02–'05; Observ. in charge Knoxville Sta., '06—; Instr. in Met. and Consult. Met., Univ. Tenn. and Expt. Sta., '09—.

1893. Henry Jackson Waters, B. Agr. (Univ. Mo., '86); *Manhattan, Kans.;* Asst. Agr., Mo. Expt. Sta., '87–'91; Prof. Agr., Pa. State Coll., '92–'95; Dean Coll. Agr. and Dir. Expt. Sta., Univ. Mo., '96–'09; Pres. Kans. State Agr. Coll., '09—.

1914. Ralph Levi Watts, B. A. (Pa. State Coll., '90), M. S. (do., '99); *State College, Pa.;* Hort. of Tenn. Expt. Sta., '90–'99; Lecturer, Farmers Institutes, Pa., Md., N. J., '99–'08; Prof. of Hort., Pa. St. Coll., '08–'12; Actg. Dean and Dir. School of Agr. and Expt. Sta., do., '12–'13; Dean and Dir., do., '13—.

1910. Herbert John Webber, B. Sc. (Univ. Nebr., '89); M. A. (do., '90), Ph. D. (Wash. Univ., St. Louis, '00); *Riverside, Cal.;* Asst. in Bot., Univ. Nebr., '89–'90; Asst., Shaw School of Bot., '90–'92; Physiol., U. S. Dept. Agr., '92–'97; in charge Plant Breeding Lab., do., '97–'07; Prof. Expt. Plant Breeding, Cornell Univ., '07–'12; Dir., Citrus Expt. Sta., and Dean, Grad. School Trop. Agr., Univ. Cal., '13—.

1896. Julius Buell Weems, B. Sc. (Md. Agr. Coll., '88), Ph. D. (Clark Univ., '94); *South Boston, Va.;* Instr. Chem. and Math., Md. Agr. Coll., '88–'89; Con. Chem., do., '91–'92; Prof. Agr. Chem. and Chem. Expt. Sta., Iowa State Coll., '95–'04; Industrial Chem., '04—.

1904. Homer Jay Wheeler, B. Sc. (Mass. Agr. Coll. and Boston Univ., '83), Ph. D. (Univ. Göttingen, '89), D. Sc. (Brown, '11); *92 State St., Boston, Mass.;* Asst. Chem., Mass. Expt. Sta., '83–'87; Chem., R. I. Expt. Sta., '89–'08; Prof. Geol., R. I. Coll., '89–'12; Prof. Agr. Chem., do., '03–'10; Acting Pres., do., '02–'03; Dir. Expt. Sta., do., '01–'12, Agron., do., '05–'12; Expert, Amer. Agr. Chem. Co., '12—.

1889. Milton Whitney, *Washington, D. C.;* Asst. Chem., Conn. Expt. Sta., '83; Supt. Expt. Farm, N. C. Expt. Sta., '86–'88; Prof. Agr., S. C. Coll., and Vice Dir. Expt. Sta., '88–'91; Soil Physicist, Md. Expt. Sta., '91–'94; Prof. Soil Physics, Md. Agr. Coll., '94–'01; Chief Bur. Soils, U. S. Dept. Agr., '94—.

1898. John Charles Whitten, B. S. (S. Dak. Agr. Coll., '91), M. S. (do., '99), Ph. D. (Univ. Halle, '02); *Columbia, Mo.;* Instr. in Hort. and Hort. Expt. Sta., S. Dak. Agr. Coll., '92; Asst. in Hort., Mo. Bot. Gard., '93–'94; Prof. Hort. and Hort. Expt. Sta., Univ. Mo., '94—.

1911. John Andreas Widtsoe, B. S. (Harvard Univ., '94), Ph. D. (Univ. Göttingen, '99); *Logan, Utah;* Chem., Utah Expt.

Sta., '94–'05; Prof. Chem., Utah Agr. Coll., '95–'05; Dir. Utah Expt. Sta., '00–'05; Dir. School of Agr., Brigham Young Univ., '05–'07; Pres., Utah Agr. Coll., '07—.

1912. JULIUS TERRASS WILLARD, B. S. (Kans. Agr. Coll., '83), M. S. (do., '86), D. Sc. (do., '08); *Manhattan, Kans.;* Asst. in Chem., Kans. Agr. Coll., '83–'87; Asst. Prof. Chem., do., '90–'96; Assoc. Prof. Chem., do., '96–'97; Prof. Appl. Chem., do., '97–'01; Prof. Chem., do., '01—; Dean, Div. Gen. Sci., do., '09—; Asst. Chem., Kans. Expt. Sta., '88–'97; Chem., do., '97—; Dir., do., '00–'06; Chem., Kans. Engin. Expt. Sta., '10—.

1912. CHARLES BURGESS WILLIAMS, B. S. (N. C. Agr. Coll., '93), M. S. (do., '96); *West Raleigh, N. C.;* Asst. Chem., N. C. Dept. Agr., '93–'06; Agron., do., '06–'07; Dir. and Agron., N. C. Expt. Sta., '07–'12; Vice Dir. and Agron., do., '13—.

1908. CARLOS GRANT WILLIAMS, *Wooster, Ohio;* Agron., Ohio Expt. Sta., '03—.

1911. WILLIAM ALPHONSO WITHERS, A. B. (Davidson Coll., '83), A. M. (do., '85); Grad. Stud. Cornell Univ., '88–'90; Fellow ib., '89–'90; *West Raleigh, N. C.;* Asst. Chem., N. C. Expt. Sta., '84–'88; Prof. Chem., N. C. Agr. Coll., '89—; Statis. Agt., U. S. Dept. Agr., '95–'02; Acting Dir., N. C. Expt. Sta., '97–'99; Chem., do., '97—.

1909. FRITZ WILHELM WOLL, B. S. (Royal Fredericks Univ., Christiana, '82), Ph. B. (do., '83), M. S. (Univ. Wis., '86), Ph. D. (do., '04); *Davis, Calif.;* Asst. Chem., Wis. Expt. Sta., '87–'97; Chem., do., '97–'13; Asst. Prof. Agr. Chem., Univ. Wis., '93–'04; Assoc. Prof., do., '04–'06; Prof., do., '06–'13; Prof. Anim. Nutr., Univ. Cal. and Expt. Sta., '13—.

1903. ALBERT FREDERICK WOODS, B. Sc. (Univ. Nebr., '90), A. M. (do., '92), D. Agr. (do., '13): *University Farm, St. Paul, Minn.;* Asst. Bot., Univ. Nebr., '91–'94; Asst. Chief Div. Veg. Path., U. S. Dept. Agr., '94–'00; Chief, do., '01–'09; Asst. Chief, Bur. Plant Indus., do., '01–'09; Dean Coll. of Agr., Univ. Minn., and Dir. Expt. Sta., '10—.

1903. CHARLES DAYTON WOODS, B. S. (Wesleyan Univ., Conn., '80), D. Sc. (honorary, Univ. Me., '05); *Orono, Me.;* Asst. Chem., Wesleyan Univ., '80–'85; Instr. Sci., Wilbraham Acad., Mass., '83–'88; Chem., Conn. Storrs Expt. Sta., '88–'96; Vice Dir., do., '89–'96; Prof. Agr., Univ. Me., '86–'03; Dir. Maine Expt. Sta., '96—.

1911. BONNEY YOUNGBLOOD, B. S. (Tex. Agr. Coll., '02), M. S. (do., '07); *College Station, Tex.;* Prin. and Instr. in Agr., Henderson, Tex., City Schools, '03–'05; Prin. and Instr. in Agr., Mineola, Tex., High School, '05–'06; Supt. City

Schools and Instr. in Agr., Pauls Valley, Okla., '06–'07; Asst. Agr., Office of Farm Management, U. S. Dept. Agr., '07–'11; Dir., Tex. Expt. Sta., '11—.

1910. C. A. Zavitz, B. Sc. (Toronto Univ., '88); *Guelph, Canada;* Asst. Expt. Dept., Ontario Agr. Coll., '86–'93; Head of Expt. Dept., '93—; Prof. of Field Husbandry, Ontario Agr. Coll., '04—.

DECEASED MEMBERS.

Robert Fairchild Kedzie,	Born	Dec.	9, 1852	Died	Feb.	13, 1882
Lauren Briggs Arnold,	"	Aug.	13, 1814	"	Mar.	7, 1888
George Hammel Cook,	"	Jan.	5, 1818	"	Sept.	22, 1889
Patrick Barry,	"	May	24, 1816	"	June	24, 1890
John J. Thomas,	"	Jan.	8, 1818	"	Feb.	22, 1895
Charles Valentine Riley,	"	Sept.	18, 1843	"	Sept.	14, 1895
Charles Lee Ingersoll,	"	Nov.	1, 1844	"	Dec.	15, 1895
Edward Louis Sturtevant,	"	Jan.	23, 1842	"	July	30, 1898
Sir John B. Lawes, *Hon. Mem.*,	"	Dec.	28, 1814	"	Aug.	31, 1900
John Alvah Myers,	"	May	29,1853	"	April	8, 1901
Sir Henry Gilbert, *Hon. Mem.*,	"	Aug.	1, 1817	"	Dec.	23, 1901
Robert Clark Kedzie,	"	Jan.	28, 1883	"	Nov.	27, 1902
Victor Hunt Lowe,	"	Sept.	23, 1869	"	Aug.	27, 1903
Henry English Alvord,	"	Mar.	11, 1844	"	Oct.	1, 1905
Robert Warington, *Hon. Mem.*,	"	Aug.	22, 1838	"	Mar.	20, 1907
Willis Grant Johnson,	"	July	4, 1866	"	Mar.	11, 1908
James Fletcher,	"	Mar.	28, 1852	"	Nov.	8, 1908
Samuel William Johnson,	"	July	3, 1830	"	July	21, 1909
William Henry Brewer,	"	Sept.	14, 1828	"	Nov.	2, 1910
Charles Anthony Goessmann,	"	June	13, 1827	"	Sept.	1, 1910
Samuel B. Green,	"	Sept.	15, 1859	"	July	11, 1910
Welton M. Munson,	"	April	6, 1866	"	Sept.	9, 1910
Edward Burnett Voorhees,	"	June	22, 1856	"	June	6, 1911
Franklin Hiram King,	"	June	8, 1848	"	Aug.	4, 1911
Oskar Kellner, *Hon. Mem.*,	"	May	13, 1851	"	Sept.	22, 1911
John Bernhardt Smith,	"	Nov.	21, 1858	"	Mar.	12, 1912
Melville Amasa Scovell,	"	Feb.	26, 1855	"	Aug.	15, 1912
Charles Edwin Bessey,	"	May	21, 1845	"	Feb.	25, 1915
Eugene Waldemar Hilgard,	"	Jan.	5, 1833	"	Jan.	8, 1916

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PROCEEDINGS

OF THE

THIRTY-SEVENTH ANNUAL MEETING

OF THE

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NOVEMBER 13 AND 14
1916

WASHINGTON, D. C.

EDITED BY THE SECRETARY

PUBLISHED BY THE SOCIETY
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CONTENTS

OFFICERS OF THE SOCIETY FOR 1917

President. . . . . .HERBERT OSBORN, Columbus, Ohio

Vice-President. . . . . .WM. D. BROOKS, Amherst, Mass.

Secretary-Treasurer. . . . . . .C. P. GILLETTE, Fort Collins, Colo.

Custodian. . . . . .W. D. HURD, Amherst, Mass.

Executive Committee. . . W. R. DODSON, Baton Rouge, La.
C. D. WOODS, Orono, Me.
DAVID FAIRCHILD, Washington, D. C.

Past Presidents

Term began		*Expired*
1880	W. J. Beal, *of Michigan*	1882
1881	W. H. Brewer, *of Connecticut*	1884
1884	H. E. Alvord, *of New York*	1886
1886	E. L. Sturtevant, *of New York*	1887
1887	R. C. Kedzie, *of Michigan*	1889
1889	C. E. Bessey, *of Nebraska*	1891
1891	I. P. Roberts, *of New York*	1893
1893	W. Saunders, *of Ontario, Canada*	1895
1895	W. R. Lazenby, *of Ohio*	1897
1897	B. D. Halsted, *of New Jersey*	1899
1899	W. J. Beal, *of Michigan*	1901
1901	W. H. Jordan, *of New York*	1903
1903	William Frear, *of Pennsylvania*	1905
1905	H. P. Armsby, *of Pennsylvania*	1907
1907	T. F. Hunt, *of Pennsylvania*	1909
1909	S. M. Tracy, *of Mississippi*	1911
1911	Eugene Davenport, *of Illinois*	1913
1913	H. J. Waters, *of Kansas*	1915
1915	Charles E. Thorne, *of Ohio*	1916
1916	Herbert Osborn, *of Ohio*	

Past Secretaries

1880	E. L. Sturtevant, *of Massachusetts*	1882
1882	G. C. Caldwell, *of New York*	1883
1883	F. A. Gulley, *of Missisippi*	1885
1885	B. D. Halsted, *of Iowa*	1886
1886	W. R. Lazenby, *of Ohio*	1891
1891	L. O. Howard, *of District of Columbia*	1893
1893	W. Frear, *of Pennsylvania*	1895
1895	C. S. Plumb, *of Indiana*	1899
1899	T. F. Hunt, *of Ohio*	1900
1900	F. M. Webster, *of Illinois*	1905
1905	F. W. Rane, *of Massachusetts*	1910
1910	E. W. Allen, *of District of Columbia*	1914
1914	L. A. Clinton, *of District of Columbia*	1916
1916	C. P. Gillette, *of Colorado*	

MINUTES OF THE 37TH ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF AGRICULTURAL SCIENCE

Held at Washington, D. C., November 13-14, 1916

The meeting was called to order by President Thorne.

The report of the Secretary-Treasurer was presented and referred to an auditing committee consisting of P. H. Rolfs, of Florida, J. C. Kendall, of New Hampshire, and C. P. Gillette, of Colorado.

A Committee on Nominations was appointed as follows: S. M. Tracy, of Mississippi; C. D. Woods, of Maine; and E A. Burnett, of Nebraska.

The Committee on Nominations reported as follows:

For President: Herbert Osborn, of Columbus, Ohio.

For Vice-President: Wm. D. Brooks, of Amherst, Mass.

For Secretary-Treasurer: C. P. Gillette, Fort Collins, Colo.

For Member of Executive Committee: W. R. Dodson, of Alabama.

For Custodian: W. D. Hurd, Amherst, Mass.

The report of the Committee was accepted and adopted.

The Executive Committee recommended the following names for membership in the Society, all of whom were elected:

D. W. Working, Washington, D. C.

George E. Morton, Fort Collins, Colo.

O. A. Beath, Laramie, Wyoming.

E. J. Kraus, Corvallis, Oregon.

H. J. Gramlich, Lincoln, Nebr.

J. H. Frandsen, Lincoln, Nebr.

Dr. Robert Stewart, Urbana, Illinois.

Alvin Kezer, Fort Collins, Colo.

The report of the Custodian was presented and accepted.

The Auditing Committee reported that the Treasurer's

books and accounts had been examined and found correct, and that a balance of $345.32 was shown in the treasury.

The President of the Society in his annual address spoke on the subject, "Our Place in the Sun." He outlined a plan of federating various societies interested in the promotion of agriculture.

The motion was made and carried that the plan of reorganization as submitted by the President of the Society be submitted to the Executive Committee with instructions that the committee make recommendations before the close of the meeting.

The Executive Committee presented the following resolution:

"RESOLVED, 1. That the American Society of Agronomy, the American Farm Management Association, and other societies organized for the advancement of scientific agriculture, be invited to join the Society for the Promotion of Agricultural Science. 2. That membership in such associations shall constitute membership in the Society for the Promotion of Agricultural Science without any additional charge for dues. 3. That the chairman of the executive committee of such associations as may accept this invitation shall constitute a committee to prepare a program for a joint session of the adhering associations to be held at the next annual meeting and shall select a temporary chairman and secretary for that session. 4. That this invitation does not contemplate any surrender of their separate organizations by such societies as may accept it."

After full discussion of this resolution the motion was made and carried that the Executive Committee be instructed to poll the membership of the Society upon the resolution as offered, regarding opening our membership to the members of the various societies organized for the promotion of agriculture; that a majority vote of the members should be considered as decisive and that the Executive Committee be instructed to act on the results of the poll.

The motion was made and carried that we adjourn.

L. A. CLINTON, Secretary.

OUR PLACE IN THE SUN

THE PRESIDENT'S ANNUAL ADDRESS

By CHARLES E. THORNE
Ohio Experiment Station

The Society for the Promotion of Agricultural Science owes its origin to an editorial by Dr. E. Lewis Sturtevant, published in the Scientific Farmer in June, 1879, in which was said:

"We need * * * not a limited, but a general science; for science is universal. Not an agricultural science, but science applied and attracted to agriculture. * * * We need a criticism, extending throughout the field of agricultural thought and work, which shall recognize what is worthy and encourage the worker, and which shall prick the bubbles of error, no matter by whom blown."

The suggestion thus made was approved at once by Dr. W. J. Beal, then of the Michigan Agricultural College, and at the meeting of the American Pomological Society, held in Rochester, New York, in September, 1879, a preliminary meeting was held, attended by six men—Doctors Beal and Sturtevant, L. B. Arnold, Patrick Barry, Professors G. C. Caldwell and J. J. Thomas—who issued a circular letter inviting a few others to join them at the next meeting of the American Association for the Advancement of Science, to be held in Boston, in August, 1880, in organizing an association having for its object "the promotion of agriculture by fostering investigations in science applied to agriculture." In response to this invitation twelve men met at the Boston meeting and organized the "Society for the Promotion of Agricultural Science."

To these men, and especially to Doctor Beal, who has given unsparingly of his time and energy to the interests of this Society, the cause of scientific agriculture owes a debt which can never be measured, and I am sure that not only the members of this Society, but those of the societies which are meeting with us tonight, will heartily join me in a testimony to Doctor Beal of our sincere respect.

At the outset I wish it to be understood that what I shall say respecting the early history of this Society is in no sense intended as a criticism. Times change and we with them, and in respect to agricultural science, great changes have taken place within recent years, so that the plan of organization which was appropriate to the conditions prevailing 37 years ago, requires material modification to meet the conditions prevailing today.

Membership in this Society was originally restricted to 40 or 50 persons, who were admitted only on special invitation, and its meetings were held in connection with those of the American Association for the Advancement of Science, usually on the Mondays and Tuesdays preceding the sessions of the general association.

During the first twelve years of its history, the members in attendance at its meetings averaged 15 persons, 20 being the largest number recorded at any meeting. In 1892 the membership limit was raised to 100, but the attendance did not increase, the average for the eight years, 1892-1899, being 14.

In 1909 the numerical limit as to membership was removed, and the last report of proceedings contains a list of 150 members, who represent the leading work of the day in agricultural science.

The sudden extension of scientific research in agriculture, consequent upon the organization of the experiment stations under the Hatch Act, in 1888, brought into this work a large number of young men, many of whom, realizing the inadequacy of their preparation for the work before them, were very desirous of opportunity to get together and compare experiences. The Society for the Promotion of Agricultural Science would have seemed to be the logical scientific home for these men, but its rules of restricted membership closed its doors to the great majority of them, and it continued to hold its meetings in connection with those of the American Association for the Advancement of Science, whereas many of those who needed the help of a scientific association were charged with the difficult administrative work concerned in the building up of the new experiment stations and felt an even greater need for help in this work than in that of scientific research. They therefore felt that the As-

sociation of Agricultural Colleges and Experiment Stations had the first claim to their allegiance.

Early in the history of the College and Station Association an attempt was made to enlarge the scope of its work so as to include the consideration, not only of administrative questions, but also those of interest to scientific workers, by the establishment of separate sections for scientific discussion; but this arrangement failed to meet the approval of a considerable part of the membership of the Association and in 1903 it was finally abandoned, and the annual conventions of the Association have since been devoted more and more to the discussion of the administrative problems consequent upon the rapid enlargement of the work of both the colleges and the stations.

As first organized under the Hatch Act, less than 400 persons were engaged in the scientific work of the experiment stations. By 1897 this number had increased to 628; by 1907, to 1,098, and by 1914, to 1,852. During the same period there has also been a large increase in the number engaged in similar work in the National Department of Agriculture, while the number of teachers required to meet the rapidly expanding demands of the colleges of agriculture and the agricultural departments of other institutions is now probably much greater than that of those engaged in scientific research.

All together, therefore, the number of those who need the help and stimulus which comes from association in a common cause and whose work would naturally lead them into such an association as the Society for the Promotion of Agricultural Science is many times greater than it was when this Society was organized.

That these men feel the need of such association is proven by the number of independent organizations which have grown up within recent years.

In the invitation which was extended by this Society in 1909 to other societies engaged in kindred work to join with it in the formation of a federated association, broad enough to include all who are in any way engaged in the promotion of agricultural knowledge, thirteen such associations were named. Some of these, it is true, are composed of men engaged in regulatory or educational work, rather than in scientific research,

but their work touches that of the investigator at so many points that there is good reason for a closer relationship.

The worker in any one of the subdivisions of agricultural development through scientific research naturally desires to meet his fellow worker in the same field, and many of his problems are of little interest to those engaged in different fields. The entomologist, for example, finds but little to interest him in the work of the chemist, while neither is especially interested in rural credit; but after all, all our work leads ultimately to the same goal—the development of a more efficient agriculture—and therefore there is urgent need that we get together for a better understanding of our problems and a more effective coordination of our work.

Moreover, many of us are more or less interested in several lines of work and desire to participate in the proceedings of more than one of the existing associations; but if their meetings are held at different times and places a waste of time and money is involved in attending them.

In December, 1907, the American Society of Agronomy adopted the following resolution:

> "Resolved: That the Executive Committee of this Society be instructed to suggest to the Society for the Promotion of Agricultural Science that this Society will be glad to render it any assistance possible in bringing about the affiliation of this and other scientific agricultural organizations into a national association for the advancement of agricultural science."

This resolution was presented at the twenty-ninth meeting of the Society for the Promotion of Agricultural Science and a committee was appointed to confer with other associations respecting the carrying of the suggestion into effect. This committee reported a tentative plan of organization at the next meeting of the association, which was adopted.

At the thirty-first meeting the question of this Society publishing a journal in cooperation or affiliation with other societies was discussed and the Executive Committee was directed to consider the matter and given power to act.

At the thirty-second meeting this Society voted to join the "Affiliated Societies of Agricultural Science" and designated its Secretary to act as its representative on the Council. From the minutes of this meeting, held at Columbus, in 1911, I quote:

> "The American Society of Agronomy, the American Society of Animal Nutrition and the American Farm Management Association held their meetings at the same time. The minutes of this Society state that this 'added to the success of the gathering, as a large number of persons interested in the progress of agricultural science were thus brought together.' This called for some adjustment of programs between the secretaries of the various societies, to avoid unnecessary conflict, and permitted the holding of three joint sessions, which were occasions of unusual interest. These were announced on the programs of the various societies, and the subjects selected for these meetings were of broad interest, so that the attendance was large and representative of the various branches of agricultural science and experimentation."

The thirty-third meeting was held at Atlanta, Ga., and joint sessions were again held with the American Society of Agronomy. From the Secretary's report of this meeting, I quote again:

> "The success of these meetings made the advantages of such joint sessions again manifest. They added to the interest of the meetings of both societies, and enabled a larger number of persons to hear the papers which were of mutual interest."

The thirty-fourth and thirty-fifth meetings, in 1913 and 1914, were both held at Washington, D. C., and at each meeting a joint session was held with the American Society of Agronomy. In 1914 the American Society of Animal Production also met at Washington, and while no joint sessions were held, the President of that Society said in his annual address:

> "Certainly we have never before had such a meeting anywhere as we are having this year in Washington. I would suggest, in view of the unprecedented success of this meeting, that we give a thorough trial to the idea of meeting at the same time and place as the Association of Agricultural Colleges and Experiment Stations, the Society for the Promotion of Agricultural Science, and other associated organizations. This would bring us every other year to Washington, the meetings on the alternate years being held at other points, and would give us the advantage of a considerable measure of fixity in the place of meeting, and also during the alternate years, the benefits of travel to other parts of the country."

At the thirty-sixth meeting, held last year at Berkeley, California, a joint session was held with the American Society of Agronomy and the American Farm Management Association.

By 1915 the membership of the Society for the Promotion of Agricultural Science had reached a total of 150; that of the American Society of Agronomy, 471, and that of the Society of Animal Production, 121. (I do not have at hand the membership in the American Farm Management Association.) Thirty members of the Society for the Promotion of Agricultural Science were also members of the Society of Agronomy, and 27 were members of the Society of Animal Production, while a few were members of all three societies, so that the total membership in the three societies was nearly 700. I am not able to give the membership in other kindred associations, but it is evident the total membership must have reached 1,000 or more.

Sixty-seven papers have been presented at the meetings of the Society for the Promotion of Agricultural Science during the last seven years. Judging by the titles, 24 of these papers would have been equally appropriate to meetings of the Society of Agronomy, and 14 to those of the Society of Animal Production; 13 dealt with subjects relating to forestry, botany, entomology, horticulture and chemistry, and 16 were more general in character. All of these papers were perfectly appropriate to a general Society for the Promotion of Agricultural

Science, were that society the only one in the field; but with independent societies occupying each of these subdivisions of science, it would seem to be time to raise the question whether we are making the best use possible of our very limited opportunities for conference by maintaining separate organizations for the discussion of the same classes of subjects.

The plan of federation suggested at the Portland meeting in 1909 proposed that each existing society retain its autonomy in every respect except that a delegate council should be chosen which should prepare a general program in which papers of general interest should be presented to joint meetings of the societies, while other papers should be referred to the affiliated society to which it would be of the greatest interest.

The plan contemplated the holding of affiliated meetings on alternate years at the same place and at nearly the same time as the meetings of the Association of American Agricultural Colleges and Experiment Stations and on the intervening years at such time and place as each of the separate societies might determine for itself.

Such an organization would lay the foundation of an association which would be to agricultural science what the great American and British Associations for the Advancement of Science are to general science. An association which would ultimately attract workers from every division of the illimitable field of natural science.

This far the proposed affiliation has resulted only in the informal joint meetings of the three societies which are represented at the present meeting, one of which—the Society of Agronomy—was the author of the first suggestion for such affiliation.

Those of you whose memory reaches back to the days when gold and silver were hidden away in old stockings and the only medium of exchange was paper currency, will remember the insistence of John Sherman that the way to resumption of specie payments was to resume. Would not similar advice apply to present conditions? Might we not agree that membership in the American Society of Agronomy and the American Farm Management Association shall constitute, *ipso facto*, membership in the Society for the Promotion of Agricultural Science,

this, however, not to exclude other persons or associations from membership?

The President and Secretary of the Society for the Promotion of Agricultural Science might be chosen at a general meeting; these, with the secretaries of the affiliated associations, to constitute an executive committee which should fix time and place of meetings and arrange programs.

Without going farther into details, which should be worked out by a committee, I offer this suggestion in the firm belief that some such plan of organization is practicable, and that the work, whether of this society or of those which might be affiliated with it, can never attain its highest usefulness until all join hands in the common cause.

The conventions of the association of colleges and stations furnish a convenient rallying point for workers in agricultural science in general because so large a number of the members of that association are engaged in this work, either as teachers or investigators; but that association has become so exclusively an official, administrative body that it does not seem practicable to include it as a constituent society in such a federation as that suggested, and it is quite possible that the greater Society for the Promotion of Agricultural Science, which is surely coming, may prefer to hold its conventions entirely independently of any other organization. This is a matter which the majority of the membership will decide for themselves.

The publication of a journal has been considered by this Society, but its small membership has hitherto made such a publication impracticable. With the larger membership that would result from the federation suggested it should be possible to maintain a journal which would be not so much an avenue for the publication of the results of scientific research in agriculture as an open forum for the discussion of all the problems connected with the promotion of agricultural science, untrammeled by any official limitations.

IMPROVING GRASSES

By W. J. BEAL
Amherst, Mass.

Forty-three years ago—1873—I began a grass garden at Michigan Agricultural College; in 1888 I began experimenting with grasses and other forage plants in thin soil in five counties of northern Michigan; and in 1890, planted at the Agricultural College five and one-half acres to grasses, clovers and other forage plants for experimenting.

In 1891, I placed in the botanic garden three plats of selections of Kentucky blue grass, one of which was large and tall, promising for forage, one small, promising for lawn. I selected nine sorts of orchard grass, four of meadow foxtail, three of sweet vernal grass. Later I secured twelve of the best varieties of timothy from Prof. A. D. Hopkins, formerly of Western Virginia, one of which blossomed early but lacked vigor.

After three years, at my urgent request, the Board of Agriculture relieved me from work in the experiment station. This left me only a very limited area for testing the grasses.

As many farmers of Michigan sow timothy with red clover for meadow, I believed a vigorous early timothy very desirable.

One of the marked objections to orchard grass is the fact that the leaves soon become harsh and are not relished by cattle and sheep. One of my selections produced long leaves that were weak and crinkled down. I multiplied by division this grass and in a similar manner another plant of orchard grass conspicuous for its stiff, harsh leaves, and got permission of the farm superintendent to grow four rods in length of these two grasses side by side. In autumn I induced the foreman to turn in some sheep and secure their opinion of the two grasses. They ate all of the crinkly-leaved grass and left the stiff-leaved one standing.

In this short note I have given my reasons for two lines of experiments with two grasses, one to secure a vigorous variety of timothy that shall blossom early, suitable to grow with red

clover, and one to secure a variety of orchard grass with tender leaves desirable for pasture.

About 1890, J. B. Olcott of South Manchester, Connecticut, displayed great energy and enthusiasm in preparing a grass garden consisting entirely of samples of grasses selected from meadow, pasture, roadside and lawn. Mr. Olcott did not propagate these grasses from seed, but transplanted the roots of certain specimens that were especially noticeable for their good qualities, cultivating them so that absolutely nothing but the desired grew and occupied the space devoted to it. After a thorough test in this way he planned ultimately to grow seed from some of the most promising, continuing from generation to generation until each would come true to seed. Before this stage of the work was performed, Mr. Olcott passed away. In answer to my recent inquiry, Director Jenkins writes: "I regret to say that nothing remains of Mr. Olcott's efforts of special advantage in agriculture." Perhaps I might add that a considerable number of racy lectures in his peculiar form of speech are on record in the reports of Secretary Gould to the Connecticut State Board of Agriculture.

Professor W. M. Hays in 1892 made some selections for Minnesota of grasses that exhibited marked peculiarities. Dr. C. V. Piper, agrostologist for the Bureau of Plant Industry, finds the difficulties of fixing races of timothy are very great. The seed from these plants, even when grown isolated or under bags, gives rise to diverse progeny. Briefly, this is our method: "Individuals are selected and only those preserved which breed fairly true in row tests; the seeds of the most promising of these are tested side by side in one-tenth-acre plats for comparative yields and only the very best as to uniformity and productivity are used for the growing of seeds in large quantities."

In 1903, Professor T. F. Hunt of Cornell University began some elaborate experiments, still continuing, with the view of obtaining improved races of timothy. These plants show great varieties in every conceivable respect. H. J. Webber, in charge in 1911, reports that "a very large number of variations selected have transmitted their characteristics in marked degree. Indeed, many of the types appear to be as uniform as any of the varieties of wheat and corn which we have in cultivation. Cer-

tain it is, they represent distinctly different types which transmit their characters. By selecting the best variations we get races that yield nearly double that obtained from the mixture of all sorts of types grown from seed bought in the market."

Judging from reports of experiments made at Cornell University, the problem of improving timothy is assured. Congratulations to Cornell and all farmers! I hope Cornell or some other station will next work with orchard grass for pasture.

PLAN OF EXPERIMENT TO DETERMINE THE EFFECT OF CROP ROTATION UPON THE PROTEIN CONTENT OF WHEAT

By J. S. JONES and C. W. COLVER
Idaho Experiment Station

Of the many and diverse problems which experiment station workers are attempting to solve, none are more fascinating than those which are concerned with the intricate processes of plant growth. In the wide range of plants grown by civilized man for his own use, perhaps none is of more importance than the wheat plant, the seed or grain of which is so widely used in the manufacture of flour for bread-making purposes. Their peculiar value in the making of light bread and their pronounced tendency to vary widely in quantity among varieties when grown under identical conditions, and in the same variety when grown under varying conditions of soil and climate, long ago brought the wheat proteins very prominently to the attention of investigators in the fields of organic and biological chemistry. The Bureaus of Chemistry and Plant Industry of the Federal Department of Agriculture, the experiment stations of eighteen or twenty states, and those of not less than a dozen foreign countries, have concerned themselves within comparatively recent times with investigations that seek a more nearly perfect knowledge of the wheat proteins and of growing conditions which determine the absolute and the relative amounts of these important constituents in the end products of growth—the seed or grain.

Decided progress has been made in those investigations which seek a better understanding of the individual wheat proteins, but advances are not quite so clear cut in that other class of investigations which aims at a better understanding of the effect of this or that factor of soil and climate upon protein synthesis in the growing parts of the plant and its transportation to and deposition within the seed. Sufficient explanation of the importance attached to relative amounts of protein in wheats of the same or of different origins lies in the fact that a leading

characteristic of strong wheats—those from which the standard bread-making flours are made—is a high protein content. Although there is something of an assumption in the belief that maintenance of a certain minimum of protein assures desirable milling wheat and that an increase of protein gives to it an increased value, there is sufficient evidence to warrant the statement that efforts made to maintain or increase the protein content of milling wheat are well directed.

Perhaps there is no section of the country where activity in this line of investigation is of greater importance than in the Intermountain and Pacific Coast states where a great deal of the wheat produced falls far below the highest grade demanded by resident millers whose product comes into competition with that of other millers who grind the hard spring and winter wheats of the northern and middle western states. Whether they are strictly just or not, recent quotations on flour in the city of Spokane, Washington, reflect the relative values placed by millers upon Pacific Coast, Intermountain and middle western grown wheat. The quotations referred to on the 25th of October, 1916, were $8 per barrel on flour ground from Washington grown wheats, $9.50 on that ground from Montana grown wheats, and $10 on the product of Dakota grown wheats. These are differences well worth the serious efforts of northwest wheat growers to eliminate.

One does not have to search far in the literature to discover that some very sweeping statements have been made with reference to the influence of climate upon protein formation in the wheat plant. It is unfortunate that these statements in many instances record conclusions reached from general observations only. They of course can be given comparatively little weight by careful investigators. We do not question certain data upon which the conclusion is based that over certain areas the protein content of the wheat crop decreases with increase of rainfall during the growing season. We do question the applicability of that conclusion to widely separated sections. If spring and summer precipitation is the determining factor, then wheats produced in what is known as the Palouse of eastern Washington and northern Idaho and in the San Joaquin and Sacramento valleys of California ought to be both richer in protein and of

higher milling value than the wheats of Minnesota and the Dakotas. The correlation of available data on composition with that on climate on a much more comprehensive scale than has heretofore been undertaken is very much needed.

We do not care to state at this time whether available data justifies the conclusion that climate is the most important factor to be reckoned with in wheat improvement from the standpoint of protein content. In passing, however, it may be well to note that if, after thorough investigation, climate appears to be the determining factor, all efforts at permanent improvement are futile unless the future efforts of our plant breeders accomplish more in that direction than they have in times past. Without further comment on the general situation with reference to wheat improvement as we view it, we will indicate very briefly our reasons for believing the question of what determines high or low protein content in milling wheat to be still an open one and why, in spite of certain very elaborate and carefully conducted investigations which have to some indicated otherwise, the soil has not yet been eliminated from those factors which make for or against a high protein content in the grain grown upon it.

Five years' data (crops of 1908 to 1912 inclusive) on Palouse Bluestem and Forty Fold grown on the Palouse silt loam with sodium nitrate and other fertilizers indicate, as a result of nitrate application, an increase of protein in the grain ranging from five to twenty-one per cent. Bluestem is a spring wheat. Forty Fold is a fall sown wheat. Similar data on Red Russian, another winter wheat, for the year 1915 indicate a gain of protein of forty-eight per cent as the direct result of nitrate application. The average protein content of wheat of this variety taken from four one-tenth-acre plats to which nitrate had been applied alone, and in combination, was 13.5 per cent—almost 4.5 per cent greater than the average from seventeen one-tenth-acre plats to which no nitrate had been applied. In any light it can be viewed, this is a substantial difference.

In the year 1909, seven one-tenth-acre plats in a field on the college farm given over to rotation work produced Bluestem wheat. Three of them had grown wheat the preceding year. The average protein content of the grain from these plats was

10.2 per cent. On three other plats the wheat followed field peas and on the fourth it followed a crop of potatoes. The wheat from these four plats was richer in protein by 30 per cent than that from the plats first mentioned—again a very substantial difference.

Glyndon Fife (Minnesota 163) and Minnesota Bluestem (169) have been grown on the college farm at Moscow since 1909. The protein content of the harvested grain in some years has been high. In other years it has been extremely low; for example, 14.65 per cent and 14.56 per cent, respectively, in 1911, and 10.46 per cent and 10.66 per cent, respectively, in 1914. Each variety has been grown repeatedly in one-tenth-acre plats under ordinary field culture, side by side, with a slightly lighter seeding in rows for cultivation—rowed culture—and with one exception with no appreciable difference in the protein content of the matured grain. In 1915 the rowed culture grain of both varieties was richer in protein than that from the ordinary field culture plats by nearly 35 per cent. In passing, it may be well to note that these wheats were also slightly richer in protein than samples of the same varieties produced the same year at St. Anthony Park, Minnesota. Our rainfall and mean temperature for the growing months, April to August, inclusive, expressed in inches and degrees Fahrenheit, were 7.65 and 58.7, respectively. Corresponding data for St. Anthony Park were 19.46 and 60.6, respectively.

Other examples of abnormally high protein in the wheat of sections where low protein is thought to be characteristic might be mentioned; two will suffice. Palouse Bluestem grown in 1915, in a field of newly broken alfalfa on a farm not far from the college farm, showed upon analysis a protein content of 13.57 per cent. This is well above the normal for that variety in the surrounding country. In neighboring fields, in a certain south Idaho county, where dry-farm practice prevails in wheat growing, the yellow berry problem in Turkey Red wheat is a perplexing one at times. Three samples of the 1916 crop show protein percentages on practically the same moisture content as follows: No. 1, 9.76 per cent; No. 2, 16.63 per cent; No. 3, 16.87 per cent. Inquiry developed the fact that No. 1 had been grown on unimproved sage brush land and that Nos. 2 and 3

had been grown on land of the same type but in fields that had just been broken from alfalfa sod. Samples 2 and 3 in protein were only slightly under that constituent in a sample of the same variety of the 1915 crop grown at Fort Hays, Kansas, and were much richer in protein that a sample of the same variety grown the same year at North Platte, Nebraska. Kansas and Nebraska are generally recognized as producers of the best grades of the Turkey Red variety.

The facts cited above are not to be used in support of any broad statement with reference to the possibilities of producing marked improvement in the wheats of the Pacific northwest. The data given were not secured from experiments planned primarily to test out the influence of soil factors upon composition. It is, however, not reasonable to ignore them or the possible fact toward which they seem to point, viz., that some factor or set of factors may so modify the prevailing normal conditions in our semi-arid soils that they in turn will react more favorably to the production of wheat of a higher than normal protein content, that is, of a crop of higher than average milling value. The factors to which we think greater importance might be attached are those concerned in the preparation of liberal amounts of available soil nitrogen.

Our plan of experiment is one that is based upon the desire to insure for the area of soil that is to be used the greatest possible activity of nitrogen-gathering bacteria and of cultural conditions that will make the fixed nitrogen readily available. Three legumes—field peas, alfalfa and red clover—in as many series will accomplish the first condition; thorough cultivation the second. An area of equal size—series 4—on which other small grains, as barley and oats, will take the place of the legumes, will constitute the check. Provision has been made for the frequent checking up on the amount of available soil nitrogen by the analysis of samples of soil taken from fallowed areas of small extent in the wheat plats. The predominating soil type on the college farm is the Palouse silt loam, but its contour is such that unusual precautions are necessary to insure uniformity of conditions and averages that will mean precisely what they express. Four varieties of wheat are to be used. Two are spring and two are winter varieties—one red and one

white under each. For any one series of tests, as series I, in which the field pea is the legume, twenty-five hundredths of an acre, exclusive of road and alley ways, will be given. This area will be divided into twenty-five plats of one one-hundredths-acre each, on five of which each year wheat will be grown after three years of a legume. These five plats are so distributed as to extend each year in one or more series diagonally across the quarter acre. At some time, therefore, during the rotation of five years, every foot of the area will have produced wheat and the units will have furnished for any one year five samples upon which to base, from the results of analytical work, an opinion regarding the value of this kind of crop rotation in raising the protein content—hence the milling value of northwestern grown wheat.

THE GRASS NEEDS OF AMERICAN AGRICULTURE

By C. V. PIPER
Bureau of Plant Industry

The crop and livestock maps of the United States, and indeed of each separate state, based on census figures, are worthy of very careful study by any one interested in the problems of American agriculture. These maps, if accurately made, show simply the cold facts. An interpretation of the facts must be based on the available knowledge concerning each area as to soils, crops and economic conditions. Naturally the interpretations of the facts by different men will differ greatly.

For the present discussion, suppose the United States to be divided into approximately equal quarters by a north and south line along the 98th meridian, and an east and west line along the parallel of 37 degrees. Call all the area west of the 98th meridian the *West;* in the eastern half of the country call two quarters the *North* and the *South,* respectively. Census figures show for the north the following data:

NORTH

	Percentage of total
Population	64
Corn	66
Hay	53
Livestock value	52
Cattle, number	45
Sheep and goats, number	31

Why does the North preponderate so greatly in the matter of livestock and forage? Is it merely relative to the denser population? Is it due to greater yield of feed stuffs per acre? Are the climatic conditions better fitted to livestock raising? Have economic conditions determined the greater attention to livestock?

Naturally all of these questions arise when one considers the

possibility of increasing livestock production in the South and West. Unquestionably the next step from a system of agriculture, based mainly on wheat or on cotton, is to one in which livestock and forage receive increased attention. Sooner or later all wheat regions are forced into a diversified farming by reduced yields, usually brought about first by increasing damage from weeds. Today the South is forced to make a great change in its agriculture due to the boll weevil, and the only change practicable is one in which livestock and forage enter as a large element. Let us first consider the status of agriculture in the North as compared with that of the South.

The observation has often been made that the agriculture of the North was, broadly speaking, imported ready made from Europe; while on the other hand, that of the South is almost as purely American in its evolution. Corn, cotton, potatoes, sweet potatoes, peanuts, beans, and various minor crops were inherited from the Indians. The other Southern crops have been gleaned from all parts of the world—cowpeas from Spain; soybeans and lespedeza from Japan; Bermuda-grass and velvet beans from India; Johnson-grass from Turkey; sorghums from China and Africa.

This contrast is even more striking when we consider grass alone, either in its strict botanical or broader agricultural meaning. Our Northern economic grasses are wholly European in origin, though the relative importance of the different species is different from those of Europe. Most striking is the preponderating importance of timothy and red clover for hay purposes and of blue-grass, redtop and white clover for pasturage. All of the remaining hay and pasture plants are of secondary importance.

In the cotton region most of these plants are of little importance and none of much value. There the pastures are largely composed of Bermuda-grass and Japan-clover, or on the sandy coastal soils, carpet-grass. All other species are of decidedly secondary importance. Hay plants comparable to timothy and red clover of the North are not known.

The low estate of livestock in the South has been ascribed to various factors, namely: First, the preponderating importance of cotton; second, the lack of forages comparable to those

of the North, and third, to climatic conditions unfavorable to livestock. The last factor may be dismissed as of little practical importance, as the work of every Southern experiment station clearly shows. It may be true that the great development of cotton culture has prevented due attention to other types of agriculture, but it is easily conceivable that if the South possessed a forage crop comparable in utility to alfalfa in the West or to timothy and red clover in the North, the present status of its agriculture would be markedly different.

The great development of livestock in the West was in marked contrast to the East, conditioned upon enormous areas of rich natural pasturage. In spite of the fact that great areas of this land have been converted into farms, in large part devoted to wheat, the livestock of the West, with the exception of sheep, has continued to increase. This result is due primarily to the culture of alfalfa and of the sorghums, which crops have more than offset the reduced acreage of range lands. The main forage problem of the West now is to secure greater returns from its farm pasture and remaining range lands. It is a perfectly safe prediction that livestock will always be a large feature of Western farming and one that will become still more important when simple wheat farming is no longer practicable.

Speaking broadly, it may be said that agriculture in the North, so far as livestock and forage is concerned, is in a relatively stable condition, the main opportunity for improvement being in growing larger crops of hay and especially in the improvement of pastures, both with the plants already being utilized. In the South a much larger attention to livestock is being forced by the boll weevil situation. While a great deal can be done with the forage crops at hand, a good perennial hay grass or legume is a great desideratum. The restorative effects of such a crop is of enormous benefit apart from the saving of labor in fitting land twice a year for annual crops. In the West there is no serious forage problem on land where alfalfa will thrive, but beyond this limit there remains much to be done in finding if possible better forages, particularly on the pasture lands too dry to leave much hope for successful farming by tillage methods.

It has already been remarked that the agriculture of the

North, with the single very important exception of corn, was inherited practically ready made from Europe. Long before the days of our experiment stations the subject of forages in the North had been well worked out, and relatively little has been added thereto in recent years. With such an admirable series of forages as corn, timothy, clovers, blue-grass and redtop, agricultural experimenters have properly devoted their energies mainly to improvement of these crops and to methods of culture including soil improvement. It is natural enough that Northern agronomists have in some cases held erroneous ideas concerning the possibilities of Northern crops in the South, such, for example, as breeding varieties of timothy or of red clover adapted to Southern conditions. But the adaptations of perennial plants are changeable only within very narrow limits. Furthermore, a forage crop which under rather adverse conditions requires continual coddling will not long receive the care it needs in a farmer's hands. Perhaps a more illuminating case is alfalfa. With suitable soil conditions this plant can be grown in every state of the Union, but in spite of vigorous propaganda less than 4 per cent of the total American acreage is east of the Mississippi River, and that mainly on unusually favorable soil types. Undoubtedly, the acreage of alfalfa in the East will increase greatly, and in time it will be grown on soils that first require expensive treatment, but, except in a few favorable soil areas, it is too much to hope that alfalfa will furnish the basis for a marked change toward livestock farming.

Any perennial hay or pasture crop to be of much value must possess the ability to maintain itself in competition with weeds; still better, if it possess the power to spread and occupy the land naturally, unless indeed it be so difficult to eradicate as to make it a weed menace, witness quack-grass and Johnson-grass. This ability of a plant to occupy the land and maintain itself against competitors may in the lack of a better term be called *aggressiveness*. It is the same trait that appears in most troublesome weeds. Indeed the same phenomenon apparently occurs in all groups of living organisms, for example, insect pests, mouse plagues, bacterial diseases. In diseases the term epidemic is applied to the phenomenon, a term also used in connection with sudden increase of animals. Aggressiveness in

plants is seemingly an expression of the same general phenomenon though usually lasting through long periods of time; however, the decrease in the vigor or aggressiveness of a plant species is not unknown, as witness the "petering out" of certain weeds. Without entering into any theoretical discussion of epidemics or aggressiveness, it is apparent that, ecologically, plants can be grouped as to their relative abilities to compete, to persist, to invade, to occupy. Among plants successful invaders are nearly always species introduced from another region with similar climatic conditions. Native species sometimes show aggressiveness as when tillage furnishes conditions which they are able to seize upon; examples, rag-weed and bitter-weed. The North was originally a wooded region with but relatively small areas of prairie. The native grasses were largely woodland species. With the clearing of the region for agricultural purposes, invading grasses from Europe soon occupied the land —witness all of our hay and pasture plants, namely, timothy, blue-grass, redtop, the clovers, orchard-grass, quack-grass, and all the rest, with a liberal sprinkling of troublesome weeds.

Some of the native Northern grasses would be useful if only they possessed aggressiveness, but in competition with the more vigorous European species they can not hold their ground. Generally speaking, the same sort of results have been secured with native grasses in the South and in the West. In spite of much testing it is significant that only one native American grass has secured a definite agricultural status, namely, slender wheat grass. It is not unlikely that some other species will be utilized when a more intensive agriculture will justify the necessary care, but, as a whole, the native species require coddling. In this connection it is worth remarking that all native American crops, namely, corn, potatoes, tobacco, beans, peanuts, pumpkins, etc., require clean cultivation.

Such considerations as these have led us to search abroad rather extensively for grasses and legumes adapted to portions of our country where none of the well known species is well adapted. There are over 5,000 species of grasses and 10,000 species of legumes known to botanists. Of more than half of these we know little, except what their botanical descriptions reveal. It is worth believing that out of this long list we ought

to find the grass or the legume fitted to each particular forage need. At any rate, until they have all been tested, it can not be said that the desired plant does not exist. The problem is quite different from that of crops used as a human food. Every one of those cultivated today was also cultivated by prehistoric man, whose ability in this respect must command our admiration. Forage crops as such are, however, a relatively recent addition to agriculture and wholly a product of Aryan civilization, since alfalfa was first cultivated in Persia. In uncivilized countries no effort was made to determine the value of native plants as forage crops, so that a huge amount of this work still remains to be done.

During the past twelve years the Department has introduced for testing about 1,000 grasses and about 1,400 legumes. As far as possible, these have been tested in every part of the country where there was reasonable hope that they might prove useful. Out of the total number only a very small percentage has actually been found valuable or promising enough to justify further attention. This does not include, of course, new varieties of crops already well known to agronomists. A brief survey of the more important of these new forages will indicate the measure of success that has been obtained. It should be borne in mind that a period of years must always elapse before the value of a new crop becomes evident. With every such introduction there is inevitably a period of booming by interested parties during which highly exaggerated statements concerning the crop are published, and this regardless of how conservative the introducer may have been in his statements.

Sudan Grass *(Andropogon Sorghum* var. *Sudanensis)*

It is still too early to determine just how important Sudan-grass will become to our agriculture, but there is no doubt that in the southwestern quarter of the United States it will be of very high value. It is the only hay grass which, under irrigation, has given yields equal to that of alfalfa. Incidentally, the discovery of Sudan-grass and related forms has thrown much light on the origin of the cultivated sorghums. Of the wild forms six have been tested fully, but Sudan-grass is by far the best of the series. Sudan-grass is probably not a truly feral form, but has

been somewhat modified by cultivation. That its existence was not long since disclosed was mainly due to its being confused by botanists with *Andropogon halepense,* Johnson-grass.

Natal Grass *(Tricholaena rosea)*

Although introduced over thirty years ago and from time to time commented on favorably in Department publications, Natal-grass did not receive much attention until about 1910. For well-drained sandy lands in southern Florida it is undoubtedly the best hay grass yet found, but it is questionable whether its value justifies the land boom which in sections of Florida has been based primarily on Natal-grass. Its merits, however, are such that there are probably over 20,000 acres of the grass grown in Florida. With the development of a better livestock industry in Florida, Natal-grass seems assured of a permanent place in our agriculture, regardless of the disappointments sure to arise from exaggerated statements and land values based on its virtues.

Giant Bermuda Grass

This is perhaps merely a variety of Bermuda obtained originally from Brazil. It is characterized by being much larger and coarser and by possessing only creeping stolons. At first some fear was felt that it might be difficult to control, but experience has shown that it is more easily destroyed than ordinary Bermuda. It is not as hardy as ordinary Bermuda, rarely surviving the winter at Washington, D. C. The much larger and more vigorous growth of Giant Bermuda make it about 25 per cent superior to ordinary Bermuda and with little doubt it will become extensively planted for pastures.

Rhodes-Grass *(Chloris Gayana)*

While Rhodes-grass is not particularly new, much additional knowledge has been secured relative to its value in this country. It is adapted as a perennial only to the warmer parts of the South, as it will not withstand a greater degree of winter cold than about 18 degrees Fahrenheit. It requires fertile soil to succeed, and under the most favorable conditions will yield

as many as six good cuttings of hay of very high quality in a season. Its greatest use will be on fertile lands in south Texas and in Florida.

Napier's Fodder Grass *(Pennisetum purpureum)*

This coarse grass is a native of South Africa, one of the several sorts known as Elephant-grass. It succeeds admirably in the warmer parts of the South and is eagerly eaten by farm animals. Its principal value will apparently be for green feeding and perhaps silage. Three cuttings six feet high can be secured in a season.

Carib-Grass *(Eriochloa subglabra)*

Carib-grass is a native of the American tropics, so closely resembling Para-grass that it is confused under the same vernacular names in tropical American countries, a fact that has led to its long neglect. In habit and adaptations it is very similar to Para-grass, but will outyield the latter considerably. It is easily propagated vegetatively. On the Everglades a field of eleven acres was established by November, 1914, from ten plants received the previous March. On the Everglades and similar lands in Florida and along the Gulf Coast, Carib-grass will, with little doubt, be extensively planted. Particularly is this true of the Everglades, which must apparently be devoted, after it is reclaimed, mainly to grasses and livestock, as otherwise the organic soil will quickly disappear.

Blue Couch Grass *(Digitaria didactyla)*

This is an Australian grass very similar in habit to Bermuda-grass. Our present knowledge indicates that it will be of approximately equal value to Bermuda, but superior for lawn purposes. This grass has heretofore been overlooked on account of its close resemblance to Bermuda-grass and the fact that the name "couch" is in Australia applied to both.

Kikuyu Grass *(Pennisetum longistylum)*

This grass is the most important native pasture grass of the highlands of Uganda and has, according to reports, given wonderful results in South Africa. It is creeping in habit and

somewhat resembles St. Augustine grass. From a single year's trial it shows much promise as a pasture grass for the Gulf Coast region.

Andropogon Grasses

The most conspicuous native perennial grasses of the Atlantic coastal and Piedmont regions are the broom sedges, grasses that not only persist on all of the less fertile soils, but which quickly invade neglected farm lands. All of the native species are high in fiber content and of little value, except for pasturage when young. The fact that this group of grasses is dominant over so large an area, has led us to test as many as possible of the foreign species in the hope that some of good forage value, together with aggressive adaptations, might be found. Of course a conspicuous example of this already is well known in Johnson-grass. While no species has yet been detected that seems likely to become aggressive after the manner of bluegrass or Bermuda, several of them possess much merit and are likely to become of considerable agricultural value. These include the following, all perennials native to India:

Chrysopogon montanus
Andropogon annulatus
" bifoveolatus
" emersus

The last mentioned is a vigorous creeping grass with excellent habit and texture for lawns and pastures. The other three are highly valued in India as natural forage. While much yet remains to be done in determining their agricultural value, the evidence justifies the belief that they will all prove of value.

Paspalums

Another group of grasses with very numerous species in the South is Paspalum, a number of which furnish considerable pasturage. Paspalum dilatatum from South America, now spread everywhere in the South, is the most valuable, but its poor seed habits militate greatly against its farm use. Only one of the numerous other species tested shows much promise, namely, Paspalum notatum, also from South America. It pro-

duces highly palatable pasturage throughout the year on the Gulf Coast, and possesses excellent seed habits. For permanent pastures it is highly promising.

Legumes

In the matter of legumes less success has attended the finding of additional species of economic value and none of the agronomically unknown ones has shown any special value. Two forage legumes are, however, worthy of comment here. The rapidly increasing use of Melilotus, Sweet or Bokhara clover, is very noteworthy. The two common species are well known as they have spread like weeds along nearly every railway and roadside in the country. While sweet clover is one of the oldest cultivated forages, its utilization in this country on any extensive scale is very recent. Two causes have brought this about, first the increasing difficulty over wide areas in securing and maintaining stands of red clover, for which sweet clover is a useful substitute. Second, the fact that sweet clover in the arid regions will yield good returns on land too dry for alfalfa. For these two purposes sweet clover is proving a real boon to American agriculture.

The other legume which impresses me as having real possibilities is kudzu. Although long since introduced and much used as porch vine, it is only in recent years that it has been considered as forage. Without doubt it is the most vigorous growing leguminous vine known under our conditions. Indeed some writers have expressed the fear that it would be impossible to control it on a farm, a groundless fear, however. At Arlington Farm we have secured during three years hay yields double as great as the best from either cowpeas or soybeans, although as a cut crop, kudzu is not so easy to handle. In my judgment, its greatest use will likely be to pasture each year's crop when fully grown, utilizing for this purpose particularly hillsides likely to erode and other poor soils on the farms. Data concerning kudzu have not accumulated rapidly due in part to the expense of planting and to the fact that the habit of the plant has not appealed as desirable. There can be little question, however, that over much of the East and South it will yield far more fodder to the acre than any other known perennial

legume, especially on relatively poor soils. This fact alone will probably insure its much larger utilization.

It will be noted that nearly every one of the new forages mentioned is adapted only to the South. This is primarily due to the fact that Northern grasses, at least for humid regions, are very much better known than tropical and subtropical species.

As to the drier portions of the United States it is well known that a very high percentage of the lowland natural forage of California is produced by aggressive annuals introduced from the Mediterranean region, such as bur clovers, alfilaria, wild oats, wild barleys, bromes, fescues and other grasses. The annual legumes and grasses in the Mediterranean region are very numerous, and with little doubt many others could be introduced to advantage, using, of course, due caution. Many of these Mediterranean species have also become abundantly dispersed in the Columbia River Basin. While many of them are not particularly desirable, they have undoubtedly added to the amount of pasturage under a system of grazing that the native species could not well withstand.

In the remaining semiarid areas no introduced grasses have as yet shown much aggressiveness. Particularly is this true of the short-grass prairies, an area apparently not duplicated in ecological character in the Old World.

Our intermountain area of the West is characterized by a bunch-grass type of vegetation very similar to the steppes of Asia. There is every reason to believe that among steppe grasses will be found species that will spread aggressively on similar areas in America, paralleling the phenomena that have taken place with blue-grass and white clover in the North, Bermuda and Japan clover in the South, and the Mediterranean plants in the Pacific States. To increase the carrying capacity of the dry range lands, this is probably the most promising lead.

None of the new forages that have been introduced in recent years can be said to have had a revolutionary effect on agriculture. Indeed "an agricultural revolution"[3] is practically always purely a paper statement, not a reality. One might indeed rather express disappointment that new crops are not more potent influences to modify agriculture. Broadly speaking, however, progress in agriculture is conditioned on so many

factors operating in conjunction, that even if a new crop plant possess very great merit, its influence works but slowly. On the whole, however, the search for new forages has been more than justified by the results secured in helping to solve the grass needs of American agriculture.

BOYS' AND GIRLS' CLUB WORK IN RELATION TO AGRICULTURAL EDUCATION

By WILLIAM D. HURD
Massachusetts Agricultural College

In discussing the subject of the relation of boys' and girls' club work to our plan of agricultural education I am assuming that the members of this society are familiar with the history of the movement, the manner in which it is organized in several of the states, and are therefore more interested in the value it has as an adjunct to our public school system and its ultimate effect on the agricultural industry of this country than in details of administration of this work.

There have been many criticisms made of our public school system—some just, some unjust. It has been said, and generally agreed to, I think, that most of the subject matter taught has been abstract, unrelated to life, the home, and other interests of the child. Methods and subject matter have not resulted, either in leading in the direction of the farm, those in cities who are adapted to the farming vocation, or in keeping on the farm those brought up on farms and better fitted for this than for other vocations. The nature study craze, and the wholesale teaching of the elementary agriculture idea has not accomplished what was expected of them, except, perhaps, to lead toward the saner and more practical ideas that are now being put into practice. The school, except in a few instances, still stands as an isolated institution, disconnected from the life of the community in which it exists. The gulf between the home and the school has not been bridged with any span yet proven to be permanent. Boys and girls from farm homes still continue to grow up with an actual distaste for farming and rural home life. The past history of the attempts made to teach agriculture in our public schools has nct been flattering. Young people who ought to stay on the farm continue to go to the city—and I make no attempt here to put forward the theory that all farm-born children should be farmers. Conditions of soil fertility, financial return from farming, social life, methods

of marketing, and all-round contentment in rural districts over the country as a whole, do not seem to be improving very rapidly. Various other agencies, such as the Scouts, Campfire Girls, Y. M. C. A. groups, etc., are doing the work formerly looked after by parents and which might have been attached to the school.

In other words, this system has not met the conditions in the ideal set forth by Professor Bishop of Iowa when he states that—

> "Agriculture is not only a business and a profession, it is also a mode of life. It is science—practice living";

or again, with the following statements taken from recent reports of the N. E. A., which say that—

> "We need an organized correlation of agricultural topics with other branches of study";

and again, that

"Our pedagogy needs to recognize some new values which are concerned especially in the teaching of agriculture."

This has been said by way of introduction to show where this matter of club work, or "junior extension work" as we are now calling it, finds its proper place and fits into our system of education.

The junior extension work movement presents these values just spoken of. It is a natural outgrowth of the nature study and elementary agriculture idea. It is more real, more vital, and has an element of financial profit in it; the competitive element gives zest and interest; agriculture is now taught without being left, as formerly, without effective application. The sole reason for developing the club work idea is to teach agriculture, not to promote prize contests or to over-emphasize the material side, although these may serve a good purpose in reaching desired ends, and it is accomplishing in a remarkable degree this purpose.

In this state we assume that it is the business of the college to teach agriculture to young people as well as to adults, hence our justification for supporting this junior extension work as

one of our principal projects. The movement in Massachusetts is of very wide-spread interest, is perhaps more free from criticism and less subject to scoffing on the part of those who are usually to be found in this class than any other line of work carried on. College authorities, school authorities, commercial interests, business men, public-spirited citizens, all recognize in this movement something not found before, and coupled with the usual interest in boys and girls, for the sake of the boys and girls themselves, it is more easily financed than other lines of work.

With an enrollment in the past of nearly seventy thousand, with the school authorities or others interested in the movement in three hundred and fifteen towns, with more than sixteen hundred teachers acting as local organizers, in most instances doing it as volunteer work, and with thousands of relatives, neighbors and friends much interested in the success of some child, no real estimate can be made of the effect on the agriculture in our commonwealth twenty or thirty years from now, to say nothing of the immediate effects of stimulation to do good work on the part of the boys and girls themselves who are registered.

Through organized club work a chance is given to teach agriculture through local application, in this state, mostly at home. It is the type of work and education that has been the boast of self-made men in the past—your forefathers and mine. These clubs afford the opportunity of giving agricultural instruction where trained vocational instructors are not employed. A large number of cities and towns have recently put in paid supervisors.

It is rapidly coming in as a most important factor in our farm bureau and county agent system. Already five counties in our state have people especially employed to give either full or part time to boys' and girls' club work.

To be most successful and most valuable, it should be developed either as a part of the school system, or as a very close adjunct to it. Adequate supervision and follow-up work are absolutely necessary. It's not how many register in the spring that counts, but how many come through with completed projects in the fall. In our state this is being solved more and

more in towns or groups of towns by engaging paid supervisors who work under the general direction of the state agent in charge. Year-round local leaders will no doubt be the next step. The cost is not great. In Massachusetts we are spending from government and state agencies scarcely twelve thousand dollars, which covers supervision, prize money for trips, and other overhead expenses incident to the supervision of the work.

The best argument I know for the value of club work, as a real educator of boys and girls, is to be found in the attitude of bankers and other business men, usually rather callous to movements of this kind. In this state, as in others, they have not been slow to see exceptional value in it, have been willing to spend thousands of dollars personally to further it, and have heartily endorsed it both privately and in public.

A good example of what the movement means in an industrial center, which of course is a factor we must deal with in our state more than in some others, is shown by the growth of the work in Brockton, which is a city of about sixty thousand people composed mostly of operatives in shoe factories. The children here have little money and tenement houses are common. A school superintendent there had the vision of what the work might be and do for these children. His motto has been, "A home for everybody and a garden for every home." His enthusiasm was contagious among the business men of that city. In 1911 a citizen provided a prize of twenty-five dollars for a garden contest, which was competed for by thirty children. In 1912 prizes of fifty dollars were offered to eleven hundred club members. In 1913 the sum of four hundred dollars was supplied by private subscriptions and twenty-five hundred children joined the clubs. The city now supports the movement, and the work of more than three thousand club members is supervised throughout the year.

Three scholarships of one hundred fifty dollars each, and two of one hundred dollars each, are provided by a private citizen, the Board of Trade, and the Farm Bureau, respectively. Besides these, there are numerous other gifts.

The interest continues to grow. At this stage Mr. Charles Holland, President of a trust company, enters the field. He loans money to children on 6 per cent notes, without security,

to buy seed potatoes, seed corn, fertilizer, and pigs. One day last spring three hundred forty-two pigs for pig club work were placed in the hands of boys and girls on this basis. The bank lost only one note, and this was through no fault of the child. An agricultural agent is now employed by this bank to look after these interests, also the matter of providing better stock and more working capital for farmers on an easy credit basis.

The faith in this movement on the part of this man and a half dozen of his associates makes the opportunity for scores of boys and girls in that community. I will mention here but two cases.

Gust Anderson was an anemic boy, the son of an upholsterer in a furniture store. The father purchased two acres of land two miles from the nearest car line. The boy walked this distance to attend school. This land was so poorly plowed that the boy found it necessary to work it all over practically by hand. The only book on agriculture which he had was "Gardening for Profit." The walls of the house were, however, bordered with the colored pages of the "Country Gentleman" and other agricultural papers. The boy was in the third year of a manual arts course. He was asked if he had any ambition for something greater than this afforded, and he said, "Yes, I want to go to the agricultural college." He was told by the principal and teachers that he wasn't capable of taking the college preparatory course. This same school superintendent interceded and he was allowed to prepare for college. Along with his school work during the last three years he has, in club work, been the first prize winner in a state-wide market garden contest, he has taken a sweepstakes prize for potatoes, and the third year he worked this land he took more than one hundred dollars' worth of produce from one-twentieth of an acre. He is a freshman in our agricultural college today.

Harry Ball, another Brockton boy, had his first garden in a box on the roof of an apartment house. His father, a carpenter, three years ago secured some land with an old house on it where this boy conducted club work. During the first summer, the father being out of work, the family was practically solely sustained by the products of this garden. During the

summer of 1915 this boy raised one hundred dollars' worth of peas, and ninety-five dollars' worth of cabbage on a plot about the size of two ordinary house lots. Last spring application was made to the bank, which I have mentioned, for a loan. A farm was purchased. Much of the debt has been cleared this year. The family has cows, hens, hay, a winter supply of vegetables. This boy also is a freshman in our college today.

The building inspector of Brockton says that there has been a falling off in the building of apartment houses, and a decided increase in the number of small homes with land around them. Those who know say that this is a result of the club work movement. This club work movement is the biggest factor in the Farm Bureau of that county, there being more than five thousand club members, including those from the city of Brockton, in that county.

I might tell you, too, of Hermine Schultz of Roslindale, a girl of thrifty German parentage now 17 years of age, who has been a successful club member for the past three years. She first took up back yard gardening, where she was a leader in the contest. She next joined the home economics, and later the canning, and garment making clubs. She has taken first rank each year and in every club. This year she supervised the garden work in her own town. She has demonstrated canning before groups of women. She acted this year as a club leader in her town and brought every member through. She is the first prize winner in a state-wide sewing contest this fall. She comes up to her eighteenth year, a strong, capable young woman, able to handle herself, direct and instruct others, and has already shown all the elements of real leadership. There is no denying that club work has been largely responsible for her development.

I might tell you of the three Estes boys, living on Windsor Mountain where it took a drive of eighteen miles for the state agent to make his visits, but they have come through; or of Willard Buckler, the pig club boy, or of dozens of instances in other clubs, but the testimony would have to be the same.

It's quite a step from the highly organized school system of the city of Brockton to the one-room rural school of Russellville, a hamlet in the town of Hadley, taught by Miss Bridget

Ryan and having an average enrollment of about twenty-five pupils, made up of Polish children and native Americans. For three years, under the inspired leadership of this teacher, club work has gone on. Treating seed potatoes for scab, and spraying for blight, first taught to the children, are now commonly practiced by the farmers of the neighborhood. Housewives testify that never before have their tables been so amply supplied with fresh vegetables as since the garden work was started—and this in a real farming district, too. Home canning has again become common since canning has been taught to the children. Warm school lunches have been served in place of the cold uninviting lunch familiar to most of us. The children's work in collecting tent caterpillar nests and those of other insects, for which they were paid twenty cents a hundred, proved an object lesson to the neighborhood in insect extermination. Garden club work, and home economics, or poultry clubs dovetail together so that the entire year may be filled.

Miss Ryan says: "It would take too long to tell of the awakening effect of our club work on the *school,* how it has made for better attendance, greater interest, not only in the immediate day's work, but in every outside thing, better individual work and greater pride in our school and community."

This Russellville school has practically 100 per cent membership in club work. The work in a small school under right leadership loses none of its attractiveness, vitality, or value. No school is too small, no stock of equipment is too meager to develop this work.

No boy or girl can carry on a club project lasting four months, or a full season, and perform all the necessary duties faithfully so that recognition is gained and admission is allowed into the groups of successful contestants without coming in contact with and absorbing many things that really educate. He or she cannot plow and prepare the soil, or care for poultry, or pigs, or make a garment, or bake a loaf of bread, or go through the process of canning fruit or vegetables, or practice drainage when necessary, or work out the rows in a garden, or select seeds and fertilizers, or combat insects and diseases, or clean up the back yard prior to gardening operations, or receive the

benefits of travel to the nation's capitol or to places of interest in his state, without coming in contact with scientific facts, whether they recognize them as such or not, and having lasting impressions made upon them; without being broadened by the business men with whom they come in contact; without learning to take bravely discouragements due to climate, rain, or other causes; without recognizing the need of co-operative relationships; without learning to respect the rights of others; and without learning lessons in community work. They will be spurred on by the competitive spirit, will be more keen and observant, and will find expression of their thoughts in the final report which they must render. In club work the boy or girl either fails to come through, or else if he does come through it is with all the exhilaration of overcoming obstacles and of winning something which is much worth while. It's a real man's job that he has accomplished.

Eight or nine years of this work, modestly but soundly started but now asssuming proportions which tax our every ability to take care of it, has led to a high degree of perfection in the work done. This is shown in the recent club exhibit in connection with the National Dairy Show at Springfield for which fifteen thousand dollars was appropriated by Congress to defray expenses. The following prizes were awarded to Massachusetts club members in ten projects: 47 first prizes; 104 second prizes; 130 third prizes; 2 fourth prizes.

Students now in our college frequently stop members of our faculty and tell them that they received their first real knowledge of and liking for things agricultural through their membership in one or another of these agricultural clubs.

Examples and instances are not scarce of how organized club work has had a remarkable effect on the career of those participating, their parents and neighbors, and generally the community in which the work goes on.

Organized either as a part of or as an adjunct to our school system, clubs in either case connect the school with the home, this being the best link that has so far been found. They inject a vitalizing element into the school itself. Subjects taught in the school become at once associated with real things outside. The school becomes a part of the community. Club work

activities become the feeders for agricultural schools and colleges.

In this state where the factory and the industrial worker are so prominent, club work encourages the owning of land and the establishing of homes which may be largely maintained by the products of this same soil.

The effect of club work on club members must not be lost sight of. Boys and girls learn to work, they learn to observe, they learn to discriminate, they learn to co-operate, they learn to describe what they do, they learn business methods, they learn to weigh and balance things according to real values, they are encouraged to read and discuss, they are broadened by their contact with others, they develop initiative and judgment, they come to the age of eighteen or nineteen able to do something with a knowledge of *how,* and the confidence that they *can* do it. Club work gets hold of boys and girls at the right state in their development for directing or redirecting their thought.

Club work is proving to have a great effect on farming and home making—the two goals to be reached. Corn, potato, pig, poultry, calf, and other clubs, conducted on scientific principles, introduce better farm practices and make for better farming, as can be instanced by examples in every state where such work has been carried on.

Canning, garment making, bread making, and other clubs associated with home economics, are bringing back into our homes almost lost arts.

The various kinds of clubs carry either to the farm or to the home those things which we are condemning our school system for leaving out.

The route back to the farm is paved far better with the subjects taken up through the club work than by the way of Greek and Latin.

An element that should not be overlooked is that under our present system of organization and supervision all of these values may be had with little and in many cases no cost to the local community, a fact not to be overlooked in the day of high tax rates under which many of our smaller towns are struggling.

Most of this work, too, is outside of the traditional course

of study and recognized classroom standards, but is it not educational? I think the product proves it.

Have I put too great value on this junior extension work in its relation to the existing school system, and have I shown too much enthusiasm for it? As one not actively engaged in the actual work of organization and supervision, but who is in sufficiently close touch so that I can see its real workings day by day, I have felt that no other movement—at least none which I have been in contact with—contained such possibilities.

I have not held it up as a panacea, nor offered it as a remedy for any of the existing ills in our educational system. It simply stands for what it is worth as one movement.

But in presenting this subject I have been thinking of the boys and girls with whom I come in contact, full of strength, energy, enthusiasm, keen of eye, eager to tell of his or her accomplishment, which can only be felt by personal work and actual achievement. I am thinking in the terms of the teacher and the school superintendent as they act as leaders in the work, of their enthusiasm for it and their testimony as to what is brought into the school system. I am trying to foresee what the ultimate effect of this work will be, when developed further and to the point it ought to be, through the co-operation of federal, state, county, district and local agencies, on the agricultural industry of this country.

The results are still invisible and intangible, but we all agree, I am sure, that work done with the coming generation will count most, and it is at least safe to say that boys' and girls' agricultural club work carried on today will be reflected in a new and improved farming and home life twenty-five years hence.

I firmly believe that a properly organized and supervised system of club work, made a part of the regular school curriculum, if you please, fostered and supported by the school officials, will help to educate our young people in real fundamental, useful things, will teach them their responsibility as future citizens, and will help greatly to prevent conditions such as we are now facing in this country.

THE PHYSIOLOGICAL REQUIREMENTS OF WHEAT AND SOYBEANS GROWING IN SAND MEDIA

By A. G. McCALL
Maryland Experiment Station

As the result of a study of literature upon the subject of behavior of plants in solution cultures the writer has become greatly impressed with the desirability of studying the effect of these solutions upon plant growth in sand cultures where some of the physical environmental conditions of the soil were present, but where the cultures are relatively unaffected by the biological complications introduced when ordinary soils are used.

The earlier workers in this field grew their plants in distilled water in which was dissolved four or more salts in varying amounts, and noted the effect upon plant growth and development. To the already voluminous literature upon the subject of plant nutrition with special reference to the physiological requirements of plants growing in solution cultures, the work of Tottingham and the publications of Shive have recently added an interesting and very important chapter. As a result of a study of the more or less complex salt solution of the earlier writers, Shive[1] has been able to make a combination of three nutrient salts which contains all of the elements essential to plant growth, with the exception of iron.

The three components of his solution are mono-potassium phosphate, calcium nitrate and magnesium sulphate, which in dilute solutions dissociate to form all of the ions that are found in the four-salt solutions of the earlier workers. In studying the effect upon plant growth of varying proportions of the salts employed, the problem is very much simplified by a reduction in the number of variable components in the solution from four to three. As a part of a general plan for the study of the fertilizer requirements of farm crops at the Maryland Experi-

[1]*Amer. Jour. Bot.*, V. 2, pp. 157-160. 191[illegible]

ment Station it has been planned to make a study of the growth rate of some of the more important agricultural plants, using the same three-salt solution as was employed by Shive, but using pure quartz sand as the substratum instead of having the roots of the plants completely immersed in the free solution. In order to secure a renewal of the nutrient solution at intervals during the growth of the plant a special method was devised, whereby the old nutrient solution could be removed and a fresh solution added to the pots without seriously disturbing the relation between the roots and the sand. In case of wheat, the seedlings were started by growing the plants in water cultures until they had attained a length of 3 to 4 cm. after which they were carefully selected for uniformity and transplanted to the sand in the pots. The soybean plants were started in a similar manner except that the seedlings were grown in sand and after selecting for uniformity, were transferred to the pots. Since a detailed description of the pots and the method of manipulation have already been published[1] it is sufficient to give but a brief discussion at this point.

The pots used were of enameled steel approximately 12x12 cm. and when filled to within 3 cm. of the top contained 1,500 grams of dry quartz sand. To secure a removal of the solution a small tube was inserted into the side of the pot near the bottom and the end screened by means of a plug of glass wool and the outer end closed by the use of a pinch cock and a short length of rubber tubing. While the seed was being germinated, the sand, previously washed several times in distilled water was weighed into the pots and distilled water added until the sand was completely saturated. An inverted funnel was then placed in position at the center of the sand surface and the pot was ready to receive the seedlings. After the plants were in place, the surface of the sand was covered with a seal of soft wax[1] and the pots were ready to receive the nutrient solution which was supplied through the inverted funnel at the same time that the surplus solution was being removed by the application of suction to the tube at the bottom of the pot.

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[1]*Soil Science*, II., No. 3, pp. 211-216. 1916.

[1]Briggs and Shantz—
U. S. Dept. of Agr. Bur. Plant Indus., Bul. 285. 1913.

It is the purpose of this paper to report the results obtained by growing wheat and soybeans in sand cultures in which the nutrient solutions were renewed at three-day intervals. The wheat used was of the Fulcaster variety and the total growth period of twenty-four days extended from May 15 to June 8, 1915. The soybeans used were a selected strain known as Ito San, Ohio No. 9100, and the total growth period of twenty-four days extended from April 4 to April 28, 1916.[2]

In order to obtain the approximate optimal total concentration, which would give the best growth, a preliminary series was grown in which the individual cultures were supplied with nutrient solutions of different total concentration but having the same proportions of the component salts.

As the result of this preliminary work it was found that a concentration between one and two atmospheres (approximately 0.25 to 0.40 per cent) maximum osmotic pressure gave the best growth of tops. Accordingly it was determined to keep the total concentration of all the solutions within this range of optimal growth. The solutions supplied to the wheat cultures had a total initial concentration of 1.75 atmospheres maximum osmotic pressure, while that supplied to the soybeans had a concentration of 1 atmosphere. In each series, 36 different proportions of the three component salts, (KH_2PO_4,$Ca(NO_3)_2$ and $Mg(SO)_4$ were used. The method employed in calculating the partial osmotic concentration of each component salt in mixtures such as this, with a fixed total osmotic concentration, was the same as that used by Tottingham[1] in connection with his four-salt solution. In determining the amount of each salt required to produce the total desired concentration it was assumed that the degree of ionization of each salt was independent of the other two, or, in other words, the assumption was made that each of the three salts would behave in the presence of the other two, in the same manner as if it was dissolved in distilled water.

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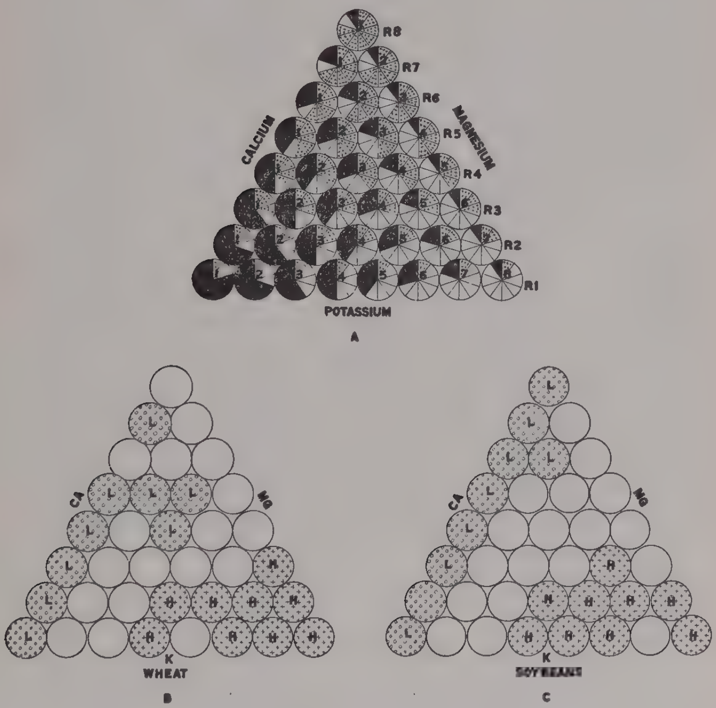
[2]The wheat cultures were grown in the Laboratory of Plant Physiology greenhouse, Johns Hopkins University, by the writer, while the soybeans were grown in the Botanical greenhouse, Ohio State University, by J. Virgil Lowe, a graduate student.

[1]*Physiol. Researches,* V. 1, pp. 133-245. 1914.

For convenience in designating the individual cultures and to give clearness to the discussion the cultures have been arranged in the form of an equilateral triangle in which the individual cultures are represented by circles. It will be observed that the diagram of Figure 1-A has eight rows, the lower one of which contains eight individual cultures. Proceed-



ing upward, each row has one culture less than the one below it, and the eighth row but a single culture. The unshaded segment in each circle represents the number of tenths of the total osmotic concentration derived from calcium nitrate, the segments colored dark, magnesium sulphate and the segments marked with small crosses indicate the number of tenths due to mono-potassium phosphate. Proceeding from the base to the apex of the triangle the rows are numbered from R1 to R8 while the individual cultures in each row are numbered from left to right. For example,

the third culture from the left in the fourth row from the base is designated as R4C3, and similarly the second culture in the third row as R3C2.

From this diagram it will be seen that all of the solutions represented in the first row have approximately one-tenth of their total osmotic concentration from mono-potassium phosphate, those in the second row two-tenths, this amount increasing by increments of one-tenth from row to row until the apex of the triangle is reached. As indicated by the shading the first culture at the left of each row has one-tenth of its osmotic pressure from calcium nitrate and it should be observed that this partial concentration increases regularly by increments of one-tenth until the opposite side of the triangle is reached. In a similar manner the partial concentration of magnesium sulphate increases from right to left in each row. The circle occupying the position R1C2 has one-tenth of its total area marked with crosses, two-tenths unshaded and seven-tenths shaded dark, thus indicating that the solution used for this culture had the osmotic proportions of one-tenth mono-potassium phosphate, two-tenths calcium nitrate and seven-tenths magnesium sulphate. Throughout the discussion the individual cultures will be designated by the row number and the position occupied in the row, using the nomenclature employed by previous writers. In this paper the two cultures are to be compared with respect to (1) dry weight of tops and (2) total transpirational water loss.

Presentation of Data

At the end of the growth period of twenty-four days, the dry weight of each culture was determined by severing the tops from the roots just above the remnant of the seed and drying the tops to constant weight in an oven heated to a temperature of approximately 102° C.

Table I gives the dry weights of tops for both the wheat and the soybean cultures, expressed (1) as the absolute weight, in grams, of dry tops and (2) as relative to the weight of culture R1C1 taken as unity.

TABLE I—DRY WEIGHT OF TOPS FOR WHEAT AND FOR SOYBEANS GROWN 24 DAYS IN SAND CULTURES

	WHEAT (6 Plants)		SOYBEANS (6 Plants)	
Culture Number	Absolute Grams	Relative to R1C1	Absolute Grams	Relative to R1C1
R1C1	0.6412	1.00L	2.1040	1.00L
C2	0.9504	1.48	2.4774	1.18
C3	1.0723	1.67	2.3400	1.11
C4	1.1276	1.75H	2.6616	1.27H
C5	1.0612	1.65	2.6374	1.25H
C6	1.1882	1.85H	2.8332	1.35H
C7	1.2181	1.90H	2.3852	1.13
C8	1.2811	2.00H	2.7750	1.32H
R2C1	0.6285	0.95L	2.0990	1.00L
C2	0.8474	1.32	2.1320	1.01
C3	1.0445	1.68	2.5100	1.19
C4	1.2770	2.00H	2.6444	1.26H
C5	1.1428	1.78H	2.7480	1.31H
C6	1.1420	1.78H	2.5778	1.23H
C7	1.4660	2.29H	2.6986	1.28H
R3C1	0.7080	1.11L	1.9718	0.94L
C2	1.0358	1.62	2.1632	1.03
C3	0.9072	1.43	2.5342	1.20
C4	1.0140	1.58	2.5850	1.23
C5	1.0810	1.71	2.6050	1.24H
C6	1.0972	1.73H	2.4190	1.15
R4C1	0.5201	0.86L	1.8740	0.89L
C2	1.0330	1.62	1.5980*	...
C3	0.8310	1.30L	2.2508*	...
C4	1.1033	1.72	2.1262*	...
C5	0.9848	1.54	0.6772*	...
R5C1	0.6822	1.07L	1.8630	0.89L
C2	0.7790	1.23L	2.2087	1.05
C3	0.7763	1.21L	2.2412	1.07
C4	0.8912	1.39	2.3982	1.14
R6C1	0.8489	1.32	1.9240	0.91L
C2	0.9151	1.43	2.1050	1.00L
C3	0.9460	1.48	2.3030	1.09
R7C1	0.6285	0.95L	1.8692	0.89L
C2	0.9540	1.50	2.3586	1.12
R8C1	0.8466	1.32	1.8018	0.86L

*Eaten by mice.

The transpiration data, given in Table II, include (1) the actual water loss from each individual culture for the entire growth period, (2) the relative water loss expressed in terms of

the loss from culture R1C1 taken as unity and (3) the water requirement per gram of dry tops.

TABLE II—TRANSPIRATION RECORD FOR WHEAT AND SOYBEANS GROWN FOR 24 DAYS IN SAND CULTURES

	WHEAT (6 Plants)		SOYBEANS (6 Plants)		WATER REQUIREMENTS	
Culture Number	Total Water Loss, Grams	Relative to R1C1	Total Water Loss, Grams	Relative to R1C1	Wheat	Soy-beans
R1C1	175.3	1.00	685	1.00	237	313
C2	245.7	1.41	631	0.96	258	255
C3	273.3	1.56	662	1.01	255	283
C4	271.2	1.55	686	1.04	240	258
C5	316.2	1.80	685	1.03	298	260
C6	321.6	1.83	693	1.05	271	245
C7	341.2	1.95	685	1.03	280	287
C8	339.9	1.94	722	1.10	266	260
R2C1	205.8	1.17	658	1.00	327	313
C2	248.3	1.42	562	0.86	293	264
C3	303.8	1.73	678	1.03	291	270
C4	353.7	2.00	696	1.05	277	263
C5	339.5	1.94	718	1.09	297	261
C6	321.8	1.83	715	1.09	282	277
C7	391.0	2.23	716	1.09	267	265
R3C1	236.3	1.34	494	0.75	334	251
C2	306.0	1.75	589	0.89	295	272
C3	263.8	1.50	624	0.95	291	246
C4	312.0	1.78	686	1.04	308	215
C5	314.8	1.79	696	1.06	291	267
C6	336.1	1.92	657	1.00	306	268
R4C1	192.2	1.09	433	0.66	270	231
C2	308.3	1.75	574	0.88	298*	...
C3	260.6	1.50	575	0.88	326*	...
C4	327.9	1.87	578	0.88	297*	...
C5	302.5	1.72	623	0.95	307*	...
R5C1	237.6	1.35	465	0.71	348	250
C2	251.4	1.44	552	0.84	323	250
C3	251.6	1.44	632	0.96	324	282
C4	289.4	1.65	643	0.98	325	268
R6C1	261.3	1.50	475	0.72	308	247
C2	306.7	1.75	549	0.83	334	261
C3	358.1	2.05	606	0.92	378	263
R7C1	208.6	1.19	493	0.75	332	263
C2	286.8	1.65	584	0.89	301	247
R8C1	277.6	1.60	479	0.72	328	266

*Eaten by mice.

To facilitate a comparison of the relative growth rates, of the individual cultures and in order to better compare the growth rate of wheat with that of soybeans, each series has been divided into three groups; (1) a lower one-fourth composed of nine cultures giving the lowest yield of tops, (2) an upper one-fourth composed of the nine cultures giving the highest yields, and (3) a medium one-half which comprises the remaining cultures. In Table I the relative yields are marked with an L if they are in the lower yield group, with an H if they are in the higher yield group. These groups of cultures with low and high values for weight of tops, are shown in the triangular diagrams of Figure 1-B and 1-C and will be referred to, always, as the *poorest* nine and the *best* nine cultures. On these diagrams the poorest nine cultures are marked L and the circles shaded with small circles while the best nine are marked H and the circles shaded with small crosses.

From an inspection of the diagrams of Figure 1 it is apparent that the proportions of nutrient salts which gave the highest growth rate for wheat, also gave the highest growth rate for the soybeans and that the proportions which gave a low yield of tops for wheat, gave a correspondingly low yield for soybeans.

The mean molecular ratios of the three nutrient salts which produced the best nine cultures and those which produced the poorest nine are given in Table III. From this table it will be seen that these values for both series of cultures are in fairly close agreement. The mean molecular ratio of magnesium sulphate to calcium nitrate for the best nine wheat cultures is 0.5 and for the best nine soybean cultures 0.8; of magnesium sulphate to mono-potassium phosphate, 1.6 for the wheat and 2.1 for the soybeans; of calcium nitrate to mono-potassium phosphate, for wheat 4.2 and for soybeans 3.9. The mean molecular ratio of magnesium sulphate to calcium nitrate for the poorest nine wheat cultures is 3.6 and for the poorest nine soybean cultures 4.1; of magnesium sulphate to mono-potassium phosphate for wheat 1.9 and for soybeans 2.2; of calcium nitrate to mono-potassium phosphate, 0.5 for the wheat and 0.3 for the soybeans. From these data it would appear that the proportion of calcium nitrate in the nutrient solution plays a very

important part, since for both species of plants here considered, good growth is associated with a *low* ratio of magnesium sulphate to calcium nitrate and a comparatively *high* ratio of calcium nitrate to mono-potassium phosphate while the ratio of magnesium sulphate to mono-potassium phosphate in these cultures appears to have had little influence in determining yields.

Table III—Mean Molecular Ratios for the Best Nine and the Poorest Nine Wheat and Soybean Cultures

Crop		Mean Molecular Ratios (Average of Nine Cultures)		
		$\frac{MgSO_4}{Ca(NO_3)_2}$	$\frac{MgSO_4}{KH_2PO_4}$	$\frac{Ca(NO_3)_2}{KH_2PO_4}$
Wheat	Best Nine	0.5	1.6	4.2
	Poorest Nine	3.6	1.9	0.5
Soybeans	Best Nine	0.8	2.1	3.9
	Poorest Nine	4.1	2.2	0.3

In Table IV is given the cation ratio values for the best nine and the poorest nine cultures of both series.

TABLE IV—RANGE AND MEAN VALUE OF CATION RATIOS FOR BEST NINE AND POOREST NINE WHEAT AND SOYBEAN CULTURES GROWN IN SAND FOR A PERIOD OF 24 DAYS.

	Culture Numbers	CATION RATIO VALUES		
		MG/CA	MG/K	CA/K
Wheat	R2C7	0.27	0.69	2.52
	R1C8	0.24L	1.39	5.77H
Cultures	R2C4	1.92	2.77	1.44
	R1C7	0.55	2.78	5.04
Best	R1C6	0.96	4.17	4.33
	R2C5	1.15	2.05	1.80
Nine	R2C6	0.64	1.38	2.16
	R1C4	2.40H	6.94H	2.88
	R3C6	0.32	0.46L	1.44L
Range		2.16	6.48	4.33
Mean		1.0	2.5	3.0
Soybean	R1C6	0.96	4.17	4.33
	R1C8	0.24L	1.39	5.77H
Cultures	R2C5	1.15	2.08	1.50
	R2C7	0.27	0.69L	2.52
Best	R1C4	2.40H	6.94H	2.88
	R2C4	1.92	2.77	1.44
Nine	R1C5	1.54	5.55	3.60
	R3C5	0.77	0.98	1.20L
	R2C6	0.64	1.38	2.16
Range		2.16	6.25	4.57
Mean		1.1	2.9	2.8
Wheat	R4C1	9.61	1.74	0.18
	R2C2	13.46	4.86	0.36
Cultures	R7C1	3.85	0.40L	0.10L
	R1C1	15.40H	11.10	0.72H
Poorest	R5C1	7.69	11.11H	0.14
	R3C1	11.53	2.78	0.24
Nine	R5C3	1.28L	0.56	0.43
	R5C2	2.88	0.83	0.29
	R4C3	1.92	1.04	0.54
Range		14.12	10.70	0.62
Mean		7.9	2.5	0.24
Soybean	R8C1	1.92	0.17L	0.09L
	R7C1	3.85	0.40	0.10
Cultures	R5C1	7.69	1.10	0.14
	R4C1	9.61	1.74	0.18
Poorest	R6C1	5.77	0.69	0.12
	R3C1	11.53	2.78	0.24
Nine	R2C1	13.46	4.86	0.36
	R1C1	15.40H	11.10H	0.72H
	R6C2	1.92L	0.46	0.24
Range		13.48	10.83	0.63
Mean		7.9	2.5	0.24

In order to better bring out the results recorded in Table IV the cation ratio values have been summarized and are given in

TABLE V—RANGE AND MEAN VALUE OF IONIC RATIOS FOR BEST NINE AND POOREST NINE WHEAT AND SOYBEAN CULTURES

		CATION RATIO VALUES					
		RANGE			MEAN		
		MG/CA	MG/K	CA/K	MG/CA	MG/K	CA/K
Best	Wheat	2.16	6.48	4.33	1.0	2.5	3.0
Nine	Soybeans	2.16	6.25	4.57	1.1	2.9	2.8
Poorest	Wheat	14.12	10.70	0.62	7.5	4.9	0.33
Nine	Soybeans	13.48	10.83	0.63	7.9	2.5	0.24

Table V. It will be seen that with respect to the range and the mean of the magnesium-calcium ratio values there is substantial agreement between the two series of cultures, good growth of both wheat and soybeans being associated with a low range and a low mean value of this ratio, while poor growth is associated with high values. With respect to the magnesium-potassium and the calcium-potassium ratio values there is a striking agreement between the two series. It will be observed that in both groups of cultures both best and poorest growth of tops are characterized by a fairly wide range of the magnesium potassium ratio values, while the calcium-potassium ratio has a medium range value for the cultures showing best growth and a very narrow range and a low mean value for the cultures showing poorest growth of tops. Attention is called to the fact that the first mentioned cation ratio is very closely related to the lime-magnesia ratio, so much discussed in recent years. Further consideration of this point will be given in the discussion of the growth curves.

Transpiration and Growth

Throughout the entire growth periods for both series, the pots were weighed and the transpirational loss was recorded at the end of each three-day interval. The total water loss for each culture was then determined by summing for the entire period, the losses thus recorded. The dry weight of the tops and the transpirational data have already been presented in Tables I and II. To bring out the close agreement between the relative water loss and the dry weight of tops these data have been plotted as shown in the graphs of Figure 2 in which the abscissas are taken to represent the different cultures and the ordinates the relative dry weights and transpirational losses relative to dry weight and water loss from R1C1 taken as unity. The two graphs in the upper part of the figure represent variations in the relative growth rates of the individual cultures of wheat and soybeans, while the lower graphs represent the variations in transpirational losses from the individual cultures. The solid lines represent the wheat data and the broken lines the soybean data.

The data presented in Tables I and II and represented by these graphs appear to support the conclusion of Whitney and Cameron and other workers in the United States Bureau of Soils to the effect that the total transpirational losses from a plant culture is proportional to the growth made by the plants during the period of time considered. It should be borne in mind, however, that these data refer only to the first twenty-four-day growth period. At the Maryland Agriculture Experiment Station it is planned to extend this investigation so as to include the later growth periods up to the full maturity of the plants.

An important feature of these graphs is the regularity with which both the growth curve and the transpiration curve rise as the proportion of calcium nitrate in the nutritive solution increases with corresponding decreases in the proportions of magnesium sulphate. It is yet to be determined, however, whether the improvement in the growth rate and this increase in transpiration is due to a more favorable ratio of calcium to magnesium, or whether it is due largely to the stimulating effect of the increased number of NO_3 radicals which accompany the increase in the calcium content of the solution. Work which

will throw some light upon this point is already in progress. It will be observed that while the general forms of the graphs are alike, those representing the dry weight of tops and the transpirational losses of the wheat cultures, rise much more abruptly and attain a much greater height than the corresponding graphs for the soybean cultures. This difference may be accounted for by the fact that the food supply stored in the large cotyledons of the soybean had a tendency to obscure, during this early growth period, the effect of the variations in the nutrient salt solutions.

Water Requirement Per Gram of Dry Tops

The ratio between the amount of water lost by transpiration and the dry weight of the plants produced is a convenient term by which to express the water requirements of the plants since such a ratio is the quantitative expression of the number of grams of transpirational water required to produce a single gram of dry substance.

In columns 5 and 6 of Table II the absolute transpiration ratios for wheat and soybeans are given. These values were obtained by dividing the total water loss from each culture by the corresponding dry weight of tops. For wheat, the mean of the values for water requirements is 307, while for soybeans the mean value of this ratio is 263. For the wheat cultures low water requirement values appear to be closely associated with low partial concentration of mono-potassium phosphate and high requirements with a low partial concentration of calcium nitrate and high partial concentration of magnesium sulphate.[1] For the soybean no such correlation is to be observed from a study of this series of cultures.

It is planned to extend this study to cover the entire growth period of several of the principal crop plants for the purpose of laying a foundation upon which to base a study of fertilizer practice in the field.

In conclusion the writer wishes to express his indebtedness to J. Virgil Lowe, graduate student in the Ohio State University, for his very careful work in connection with the growing of the soybean cultures.

[1] *Soil Science,* V. II, No. 3, p. 244. Sept. 1916.

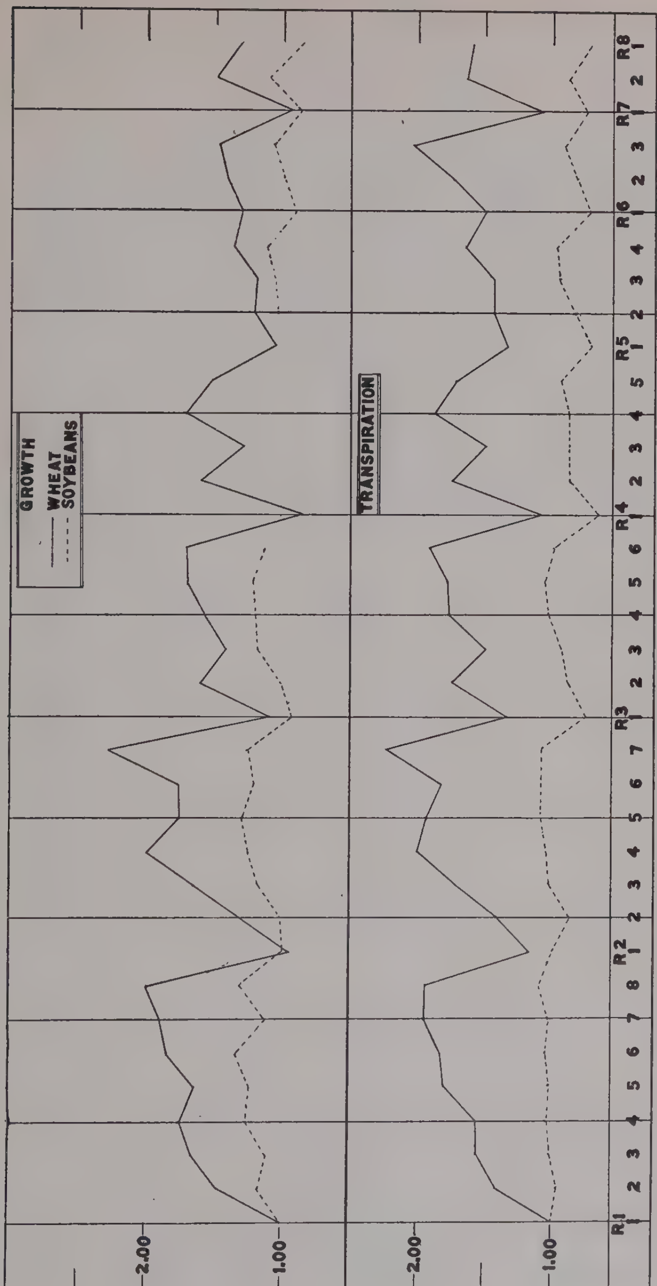


FIGURE 1. Triangular diagrams showing (A) the proportions of nutrient salts used in each culture, (B) the location of the best nine and the poorest nine wheat cultures, and (C) the location of the best nine and the poorest nine soybean cultures.

FIGURE 2. Relative transpiration and dry weight of tops for wheat and for soybeans grown in sand cultures for a period of 24 days.

OBSERVATIONS ON MEADOW INSECTS

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The insect pests in meadows occupy a somewhat different position than the pests of most other crops and have been neglected in treatment particularly because of the fact that these crops are less intensive and there has been less demand for investigation of them, because of the obscurity of the insects themselves and the fact that their drain upon the grass crop is not recognized, except in cases involving a complete destruction of the crop.

The grass crops differ from most other cultivated crops in being more like the primitive or uncultivated lands, and especially where grass remains for a long series of years on the same ground, the conditions approach in many ways those to be found in quite distinctly primitive locations. The parallel to these conditions may be found in the primitive indigenous grass vegetation of the prairie and plains lands of the west or of the open unforested tracts of the Mississippi Valley, and perhaps most clearly in the plateau regions west of the Missouri to the Rocky Mountains. There the native vegetation consists very largely of species of grasses which have become adapted to the conditions of climate and have also become adjusted to a very large population of insects and other organisms which depend upon the growth of the grass as their primary basis of support. On this basis is developed an immense number of smaller organisms feeding directly upon the grass, also many larger species, including jack rabbits, antelope, and formerly the Buffalo, but with these there are also many parasitic or predacious forms which prey upon the herbivorous forms so that there is a complex adjustment including the hundreds or thousands of different species which maintain themselves in a fairly constant balance throughout long periods of time. Such an adjustment as this may be conceived of as having been established in the distant geological past and having been maintained through long periods of time up to the present.

In the establishment of cultivated pastures or meadows with the introduction of a single species or a few particularly selected

species of grass in a certain area this original balance has been disturbed. But if such crops are maintained through a considerable series of years there is, it appears to me, a tendency to re-establish the primitive adjustment and for the grass land to represent, in some degree, the primitive adaptations or adjustments established in uncultivated areas. Perhaps this condition is more emphasized in connection with certain species of grasses which were probably native to this country and which have been utilized in the development of our agriculture. For instance, of the common grasses, timothy is an introduced species and in its cultivation we note a number of points in which there is a distinct difference from the conditions observed for blue grass, redtop, and some other species which are native to the country. While it is not the purpose here to give any detailed notice of the grass feeding insects a brief survey of the most important groups including grass pests may be useful as a basis for the consideration of certain problems for control.

Of the lower groups of insects the grasshoppers present very conspicuous examples of grass-feeding species, and there are many different kinds which, working together, constitute a heavy drain upon these crops. Often with the exhaustion of the ordinary food supply they migrate into adjacent fields or into orchards in order to secure additional food. The meadow grasshoppers, while perhaps less conspicuous or numerous, add their quota to the drain, and crickets also form in some cases a distinctly important addition to the grass-feeding species. The Thrips, while too minute to be recognized except by careful examination, occur in such enormous numbers as to constitute in many cases a very serious drain upon the crop. Their work is recognized by wilting or withering of the leaves or heads. With the Hemiptera there are many families that include grass feeding species, all of these being suctorial in habit and their injury resulting in withering of the plants. Among these the Leaf Hoppers are the most conspicuous and these occur sometimes at the rate of millions to the acre. Many aphids occurring either on the leaves or down on the roots are to be considered as important pests, often working in the same fields in conjunction with other crops. The Chinch Bug, while not appreciated so much as a grass pest, is a quite constant member of the

aggregation and must be counted among the grass species. Also the plant bugs, affecting both grasses and clovers, are to be noted here.

The Sod Worms occur in many different species, and while they are destructive, attacks are occasional and seldom recognized as serious in ordinary years, but they occur so regularly that, with the other pests, the effect is extremely detrimental. Cut Worms also form a conspicuous part of the assemblage of grass-feeding species and of these there are so many kinds that it would be useless to attempt enumeration, although such conspicuous forms as the Army Worm, Wheat-head Army Worm, and the Fall Army Worm, whose attacks occasionally result in devastation, have been recognized and studied.

We have also many species of butterflies and skippers, the larvae of which are residents of pastures and meadows, and which contribute their share in the crop reduction. The Clover-seed Caterpillar is occasionally so abundant as to attract attention and the Clover-seed Midge, the Clover Leaf Weevil, and the Alfalfa Weevil have become well known on account of their importance.

Wireworms form another group of destructive species, but since their work is mainly underground, their attacks are seldom observed and they are better known as pests in corn fields, or for other crops which have been planted upon land which was formerly in grass. They are primarily grass-feeding species and must be counted a steady drain on this crop. Along with these we may have the White Grubs which are very widely distributed, occur in immense numbers, which even though hidden underground, may so completely destroy the plants as to have a very evident effect and force the change of crop.

It would be impossible to estimate with any accuracy the precise number of species which may form the aggregation of grass-feeding insects, much less to give exact estimates of the numbers of individuals per acre in the different groups that may be so associated. A rough guess might give us 50,000 grasshoppers, 25,000 meadow grasshoppers, 2,000,000 Thrips, 1,000,000 Leaf Hoppers, 100,000 Chinch Bugs, 50,000 Plant Bugs, 50,000 Cut Worms, 100,000 White Grubs, as an aggregation that might be found in a single meadow which had been

for a number of years kept in grass. Manifestly, such an aggregation must have a very decided effect in the production of a grass crop. These by no means tell the whole story of the insect association or combination which may be present in such a field. It may in any particular case include hundreds of different species and many millions of individuals per acre.

The Meadow an Ecologic Unit

The meadow then presents us with a fairly well marked ecologic unit and if we proceed to analyze this unit we shall find it composed of a number of very well defined elements.

First—We have upon the principal grass crop, the basic element in the association, an assemblage of insects that feed directly upon the grass, and among these are the directly destructive species, such as grasshoppers, leafhoppers, white grubs, wireworms, sod-worms, root-lice, cutworms, etc.

Second—Associated with and dependent upon the grass-feeders are hosts of predacious species scattered through many orders and represented particularly by the damsel bugs, the spiders, ground beetles and Geocorids along with numerous species of birds and the mole, squirrels, some mice and the skunk among the mammals.

Third—The parasitic species including fungi, worms, acarids, and insects that are dependent upon the primary insect population for their existence. There is an innumerable host of these and probably only a small fraction of the species are as yet known. Insofar as they are primary parasites on the destructive species they are to be considered as a valuable check upon the multiplication of the injurious forms.

Fourth—There is a considerable assemblage of associated forms in the groups of scavangers and visitors that, while not so directly related to the crop, are dependent upon the debris, the blossoms or other connection for their food or food materials for their young.

The Sources of Our Meadow Insects

While the origin of our meadow and pasture pests has not been a matter of as much study or, apparently, on the surface, of as much importance as the pests of some other crops, still we must recognize two quite different sources for these insects.

First—We have the native species which, so far as we can determine, have been occupants of this geographical region for an indefinite time and, if not strictly indigenous, are at least to be counted as part of the fauna which was present before settlement by the white man and the subsequent introduction of cultivated crops from other countries. From this element we have a considerable body of species which have adapted themselves to the cultivated meadow grasses and clover and some of these, notably the grasshoppers, leafhoppers, wireworms, white grubs, etc., are among the most serious pests.

Second—For the introduced species we may recognize two groups, (a) those which have been introduced from Europe or other distant country in connection with the crops infested or, by the aid of commerce, and (b) those which have migrated by slow stages from adjacent regions mainly from the subtropical by way of Mexico or possibly Florida.

Among the introduced species that have long been recognized as of first importance are such species as the clover-seed midge, clover leaf weevil, and alfalfa weevil, while the less commonly noticed timothy thrips *(Chirothrips manicatus)* and perhaps other species of Thysanoptera, and I believe quite certainly the common Meadow Plantbug *(Miris dolobrata)*. That there are many other meadow pests in Europe that may be introduced and which we would be wise to guard against by every precaution possible is a conclusion which would seem to need no argument.

Problems in Control

In our work so far with meadow insects the tendency has been to deal with individual species and considerable progress has been made in the tracing of the life histories of certain species and the determination of facts which may assist in securing measures for control. However, the species are so numerous, the control measures so various, that it will be a long time before anything like adequate knowledge for control of all the meadow pests can be gained. Moreover, in the control of these species it becomes very apparent that measures which might be available for one species would, from differences in the life cycle, be entirely unavailable for other species, even perhaps those closely

related or in the same group. It seems necessary, therefore, that the control problem should be approached from the standpoint of the aggregate or of the ecologic combination included in the meadow or pasture, and while this involves a thorough study of the life histories and habits, it involves also the adjustment of these factors to a plan of operation which is possible as a part of the program involved in the management of the grass lands. There is a great fluctuation in the numbers of the grass insects from year to year and from place to place, and to give specific directions applying to any one species, so that the farmer could treat a pasture or meadow for such species, would be, with our present knowledge, extremely difficult.

Of the available measures for control the most positive is the rotation of crops, which of course is practiced with other objects in view, but which incidentally is of special service in the control of meadow pests. However, rotation, considered as a measure for insect control is, it seems to me, an extremely expensive plan, since it involves the change from grass to other crops at a time when, except for the insect attack, the crop should be at its maximum of productiveness. Again, there are many instances where rotation is undesirable or impossible and measures for control for such areas become a pressing problem. Along with rotation is the question of treatment for fence rows on the borders of waste land which may include the grasses which furnish the basis of survival for the grass insects. Attention to these would very greatly assist the effectiveness of the rotation method by securing more nearly an extermination of the grass pests. Much is necessary in connection with the adoption of plans of culture, time of applying, sequence of crops, etc., to assist in this direction. As a mechanical treatment. the use of the Hopper Dozer has given the most promise of advantage, and in many cases is available, but for especially rough land is somewhat difficult to apply. The use of insecticides is for the most part prohibited by the expense or labor as compared with the profit to be derived, but experiments in this line are desirable, and especially experiments with insecticides which may combine some fertilizer qualities. Some promise may be found in the use of soil fumigation for some of the under-

ground species, but here again experiments are necessary for determination of actual profit.

In the selection of species of grasses there is considerable restriction among many of the grass insects with reference to the kinds of grass attacked and some advantage may be gained by the selection of grasses which will be least sought by insects.

Another matter which deserves perhaps more consideration than has been given it, is the introduction of meadow insects from other countries. We know that a number of injurious species, especially those affecting the introduced grasses such as timothy and orchard grasses, can be accompanied by their natural insect pests and probably some of the most destructive species now affecting these crops were introduced in some way or other after the introduction of the host plant. It becomes important, therefore, that an effort should be made to prevent the introduction of such species in the future, and careful attention must be given to exclude such species as are known to be troublesome in other countries and to include, if possible, grass pests among those insects which are to be quarantined against.

While the usual estimates placed upon loss by grass insects is put at 10 per cent of the total grass crop, this estimate is probably far below that which occurs, at least in all meadows and pastures of a few years standing. In old meadows it certainly can not be less than 25 to 30 or perhaps 50 per cent, and in some cases must run much higher. I believe that this loss is one which must be recognized and that there is every reason why there should be a thorough investigation of the conditions connected with the injuries and possible control of such species and that it can best be accomplished by a comprehensive study which recognizes the association of the many different kinds of insects occurring together in this particular habitat.

THE STRAW MULCH IN ORCHARD MANAGEMENT IN CALIFORNIA

By CHAS. B. LIPMAN
University of California

Brief and bloodless though it has been, the battle between different schools of thought with regard to the causes of the lack or presence of productivity in soils has been a bitter one. In quick succession there have passed in all their phases, through our voluminous literature, the plant food theory, the root toxin theory, the protozoan theory, the parasitic fungus theory, and others of minor interest. It is not my purpose at this time and place to hold a brief for any or all of the aforementioned theories, nor yet to relegate them to the domain of "innocuous desuetude." It suffices for the purpose of my subject today merely to point out that the proponents and supporters of all the theories mentioned have never attempted to deny the paramount role of organic matter in the determination of a soil's productivity. Also that the concensus of opinion among soil investigators generally seems to be crystallizing for practical purposes into the doctrine that the maintenance of a good organic matter supply and a neutral or a slightly alkaline reaction constitute the *sine qua non* for the maintenance of fertility in most mineral soils.

On the seemingly justified conclusion, therefore, that we are all agreed on the primacy of the organic matter question in soil fertility considerations, permit me to ask what we have done in soil management to recognize it? Have we promoted the maintenance of organic matter in soils by tillage? Most certainly not. For stirring, and therefore increasing the oxygen supply and raising the temperature of soil are the very conditions under which organic matter disappears most rapidly. Have we made up losses by the use of barnyard manure? No, we have not, adequately, primarily because it is difficult to obtain such manure and its large cost is often prohibitive. Moreover, we have never been able, excepting under very unusual circumstances, to use enough of it per acre to compen-

sate soils for the enormous losses which they sustain, and much the same considerations hold for green manures. We have certainly not contributed quantities of organic matter worthy of mention by means of commercial fertilizers. Nor have we plowed under enough stubble and straw to make good the large loss occasioned by direct oxidation of organic matter in soil which is frequently cultivated and plowed. It seems, therefore, that the trend of all our soil management procedure has been to accomplish a net loss in soil organic matter, which increases in magnitude as year succeeds year.

What can be done, we ask, to stem the tide of the depletion of organic matter in soils with all the detrimental effects which follow in the wake thereof? The answer to this question is twofold. In the first place, we shall have to incorporate into the soil more organic matter than we have in the past through the systematic use of barnyard and green manures on a large scale, and in the second place, and this is the primary purpose of my brief statement to you, we must conserve the organic matter by cutting down as much as possible on the chances for rapid oxidation thereof from the soil. I need not dwell here on the improved methods which are necessary for establishing a more efficient system for the use of barnyard and green manures than that which now obtains. It is, however, in my opinion, of great importance to emphasize the arguments for, and the present status of one of the most important measures for the conservation of soil organic matter, namely, the straw mulch.

The idea of using straw as a protective soil covering primarily for the purpose of conserving moisture is of course an old one. The experience of gardeners the world over has long since taught us the great value of straw and manure mulches for garden crops of one kind or another, including berries. Moreover, there are results of experiments on record obtained at the New York Agricultural Experiment Station at Geneva, which show conclusively the great superiority of the straw mulch over the dust mulch as a moisture conserver.

My object now, however, in making this statement is to emphasize primarily the power of the straw mulch to conserve the organic matter and that peculiarly mellow condition of soil

which is recognized far and wide as the ideal condition of tilth in soils. I am therefore assuming that with these brief statements the importance of the straw mulch as a moisture conserver will be clearly kept in mind and that it needs no further discussion here.

Why then should we advocate the use of the straw mulch in all climatic regions, and particularly in those of California? Merely from the point of view of the organic matter conservation and of the maintenance of ideal tilth. Our experiences have shown that soils covered with straw to a depth of three to four inches were from three to four degrees Centigrade cooler in the summer time than similar soil alongside which was merely clean cultivated. When one stops to look for the cause of this condition, it is, of course, not difficult to determine. The prevention of the effect of the direct rays of the sun on the soil by the straw mulch, which permits a smaller heat absorption than would otherwise be the case, is responsible for a lower temperature. This, taken together with a smaller supply of oxygen, which results from the covered condition of the soil and its unstirred condition, reduces to a very great degree the direct oxidation of the carbon and hydrogen, particularly of the soil organic matter.

The result is that organic matter from the lower layers of the straw mulch soon begins to become a part of the soil and, because it disappears only with relative slowness, it yields a net gain in organic matter to the soil. The fact that this is so is attested by our experiments, which, of course, can not be given here in detail, but which show that the bacterial numbers increase in soil by virtue of the organic matter it contains, and which show, moreover, that the number of insects in various stages of development, and of worms, increases to a large degree. From all of these life activities the soil assumes a deeper color and becomes very loose and friable, thus making possible a much larger moisture absorption from either the rain or irrigation supply. These statements describe in brief the conditions which have actually been found to exist in soils which have been mulched experimentally. I might add also that just as the straw mulch is responsible for a low summer temperature of the soil it prevents the radiation back of heat in the winter time,

to such an extent, as to make the soil from two to three degrees warmer in that season than the soil which is not mulched.

The experiments referred to have been carried on on a large scale in the field, and therefore are not the same as those which have been carried on merely in the garden, and which have been known to give such good results in the past.

Aside from the improvement which has taken place in the soil in our experiment, as above described, the effect on the crop of fruit and on the appearance of the trees, which in our case were lemon trees, was remarkable in less than one year after the straw mulch had been applied. Trees which had become yellow, due in my opinion in large degree to a lack of available nitrogen and poor conditions of soil for a period of years, turned within eight or nine months to a deep green color and have continued to improve ever since at a rapid rate. The crop of fruit they bear at the present time is enormous and promises well for the continued vigor of the trees.

The writer of this paper is not an advocate of the idea that the *natural* condition of a soil is the one to attempt to approach in practical agriculture for the mere reason that it is the *natural* condition. On the other hand, he feels that we should not disregard those natural conditions surrounding the soil and producing tree growth, which may give us a hint as to what the ideal condition for that purpose really should be.

In view of that, I want to call to your attention the following facts. In the advancement of horticultural practice we have, it is true, very much modified the tops of trees by means of budding and grafting, but throughout all of that improvement the roots of trees have remained virtually the same as they were in their wild condition. For example, the orange root and lemon root are virtually the same as they were under jungle conditions and probably much the same is true for any tree which is found in its wild state among other trees on a soil that is untouched and hence is accumulating organic matter. Now what we do in practice is to take roots of trees like these (and this is particularly true under California conditions) and put them under the other extremes of soil, temperature, moisture, and organic matter conditions by setting them out in a soil which is very deficient in organic matter relatively. Moreover,

we continue to aggravate that poor organic matter condition by constant tillage and excessive cultivation, which must result in a soil condition detrimental to the well being of the tree for reasons touched on or implied in the statements above. What wonder, therefore, that physiological diseases occur?

My claim is, therefore, that we must go back to a condition in our orchard soil which simulates as closely as possible the forest soil condition, if we desire to obtain results. This is, of course, particularly true for California conditions. That it is not altogether true of California conditions alone is demonstrated by horticulturists in the eastern states, among whom may be particularly mentioned, J. P. Stewart of the Pennsylvania Agricultural Experiment Station.

So far as other matters are concerned which affect the straw mulch, I may briefly refer to the kinds of straw which may be used for the purpose. The best straws, naturally, owing to the nitrogen conditions involved, are the legume straws and hays. If those are unavailable or too costly the grain straws will do. If they are not available, pine needles may be used, and we find in our experiments that even wood shavings and sawdust, as well as prunings from trees, may be made to serve. In other words, any material which will give a cover of from three to four inches thick will serve for the purpose of mulching. Naturally, the cheapest material which can be had under given circumstances must be chosen. The argument which is given against the straw mulch on a large scale is that straw costs too much. In answer to this argument, I beg to call to your attention the fact which is especially true under arid conditions, that the saving on the cost of irrigation operations by the conservation of moisture through the straw mulch, the doing away with tillage and the cost of implements and horses which it involves, and reducing to a considerable extent the fertilizer bill, will easily make up for the initial expenditure for the straw mulch. Moreover, the initial expenditure will be largest and the cost of the upkeep of the mulch will continue to become smaller as year succeeds year. If there should not be sufficient straw for large acreages, it is our business to co-operate so that it may be produced in large quantities for use in mulching, but that straw mulching is a rational procedure and that it may even mean the

saving of many of our orchards in California and elsewhere will become patent to anyone who will study the question carefully. Above all advantages which the straw mulch system has in the orchard is the opportunity which it gives the trees of using the surface soil, which is always the best soil that there is, and particularly is this true under humid conditions where there is none too much of active soil. I can not stop now to give you many other arguments in favor of the straw mulch and of discontinuing our old tillage system in the orchards since my time is much too limited to do the subject justice. All the details of our experiments and a full treatment of the subject will be found in a future bulletin of the California Experiment Station which I hope will be issued soon.

I may at this point, however, mention one serious possible difficulty with the straw mulch, and that is the danger from fire which it may entail. In the tree or four years of experimental work with the straw mulch in different parts of California we have thus far not had the slightest difficulty from that source in the orchard. I do not deny, however, for a minute that the danger is not there, and that constitutes one argument against the straw mulch. I can merely say, however, in commenting on it, that we shall have to take a certain amount of risk in any system that we adopt in the orchard, and I suppose that same truth will hold in so far as the straw mulch is concerned. What the future may bring on this side of the subject I am unable to say at the present time. The experiments with the straw mulch on a considerable scale thus far do not give us leave to be unduly alarmed.

FOREST DEPREDATION AND UTILIZATION

By FRANK WM. RANE
State Forester of Massachusetts

It is hardly necessary to emphasize to an American the fact that forests are primarily used in our industries, for we have been only too cognizant of the truth of this statement from resultant conditions.

Without going into the discussion of wasteful and deplorable forest methods, it is the purpose of this paper to point out wherein practical forestry may aid in the solution of many perplexing forest problems.

By forest depredations we include a very large number of troubles, the more important of which are damage to forests from fire, disease, insects, wind and animals.

In a comparatively new country like ours where practically no attention was given to future conditions, and where due consideration is gained only by severe experience, we awaken to find many disastrous things have been done which now must be rectified.

The problems now are many and complicated, and they could have been avoided with comparatively little effort, if we had had our present knowledge.

In forest troubles coming from insects and diseases, we are finding, as was the case in the fruit-growing industry, our greater troubles come from introduced or so-called foreign insects and diseases brought to us usually on imported stock. Steps have been taken to regulate future importations through careful inspections and powers of restriction, but this is of little use in overcoming and neutralizing the depredations of those already established.

It is these insects and diseases that are causing us a great amount of trouble. To cope with these unwelcome guests has proven in many cases extremely troublesome and expensive.

The writer has had much experience with forest depredations, and the results secured through a careful study of

utilization as a practical aid in the solution of a few of our forest troubles in Massachusetts seem very encouraging.

This probably explains why the secretary of this society has asked the writer to discuss at this time, first, the latest developments in the work of suppression of the gypsy and brown-tail moths in Massachusetts, and, second, the present status of the chestnut blight and the blister rust diseases of more recent years.

In order to succeed in aiding the woodland owner in our state in his fight against the invasion of his forest growth by pests, a very careful and complete survey of the whole question of markets, materials, labor costs, cost of teaming, transportation charges, milling expenses, supervision, etc., was made in order to utilize all dormant capital possible, which otherwise would be almost a total loss. This study has proved worth the effort, as not only have we been able to make the sale of forest products self-supporting, but in many cases a substantial net revenue has been secured.

For a number of years the gypsy and brown-tail moth work was confined largely to shade trees and orchards, and the work of combating and suppressing these insects was directed towards overcoming the great loss following their ravages measured largely in aesthetic values.

As was inevitable, although the very best brains of the nation assisted by experts from abroad were focussed upon the suppression of these insects, the spread continued throughout the forests of the eastern part of the state. As these insects became intrenched in our woodlands, which are composed of a great variety ranging from valueless scrub and brush growth to superior stands, the same methods practiced upon preservation of trees in cities and towns were prohibitive on account of the great expense entailed. It was found that to spray an acre of woodland of average conditions with arsenate of lead, for example, would cost $40, while the assessed value of the whole property might not average that amount.

Anticipating these conditions, the Massachusetts State Forester set at work to meet the situation, and in a year's time evolved a spraying machine that revolutionized all previous methods. This machine was constructed of parts made of

bronze metal instead of cast iron and perfected in such a way as to obtain greater efficiency in spraying and at the same time reduce the expense of operation. The result of this improvement in our spraying equipment was to lower the comparative cost of woodland spraying from $40 to $6 per acre. In accomplishing this result, the State Forester desires to acknowledge the assistance of L. H. Worthley and Melvin Guptill. The former was an assistant in the department in charge of moth work and the latter was responsible for executing the engineering work. This powerful machine, making possible the spraying of tall trees without climbing, is economical of team and manual labor. No patents were ever applied for and the results were given to the world. This machine has been in common use in Massachusetts and elsewhere, and, aside from the natural improvements suggested from experience and minor inventions each year, is the same machine.

Other methods of moth suppression besides spraying have been used, such as introducing parasites, creosoting egg masses, etc., all of which are of value when used intelligently, but spraying is commonly resorted to when immediate results are desired. During the past season the contract for arsenate of lead by the State Forester was for 700 tons, and it is believed that 1,000 tons may have been used in Massachusetts.

As soon as the moths began to make inroads into the forests, we were confronted not only with improving and perfecting our spraying methods but other economic measures suggested themselves.

It was found to be a poor policy to spray good, bad and indifferent trees alike. It naturally followed, therefore, that the undesirable ones were taken out, thus enabling the remaining trees to be sprayed more economically.

Herein lies the main thought of this discussion, the point to be emphasized, namely, forest utilization in connnection with depredations.

The chief purpose of the forester is to bring order and system out of chaos, and meanwhile to determine ways and means of reducing our methods to scientific and economic practice.

Upon studying the moth situation from the broad stand-

point of future results when applied to forest conditions, the correct method of procedure was self-evident. As already indicated, it was an advantage to thin the forests to accomplish better spraying, and this practice naturally fell to the trained forester.

As soon as modern forestry practices were applied and sylvicultural studies made, better results followed. It was soon demonstrated that certain trees were the natural food of the moths while others were to a greater or lesser extent immune from their attack, and particularly so when in so-called clear stands or in mixtures with other species equally undesirable as moth food.

Taking advantage of these fundamentals and encouraged by actual results from the field experience, the so-called forestry methods of moth control have rapidly come to the front. During the past few years the State Forester has executed some large forest operations which have not only proven satisfactory in handling the moths, but from the economic standpoint have aided in establishing better forestry practices. The result from moth invasion in woodlands was to throw upon the market an oversupply of dead and dying forest products.

The forests of eastern Massachusetts are the remains of a culled-out and cut-over country which has restocked itself without regulation or future concern. All sorts of forest types, species, mixtures, ages and conditions are found.

When the moths invade these woodlands they readily find enough of such species as they prefer to live upon until they are fairly grown, and then, if compelled to do so, they finish their feeding period on whatever remains for them to devour.

Taking advantage of this fact, we have inaugurated the practice of taking out those species upon which the insects thrive best, their so-called natural food trees, with the result that the conditions are unhealthy for their propagation. The evergreens, the white pine in particular, one of our most valued species, we find are practically immune from the gypsy moth when grown in clear stands, for the reason that the very young caterpillars are unable to eat the needles. Hence, if there are no deciduous trees present upon which they may feed during their earlier stages of existence, the pine is unmolested. Had this fact alone

been known earlier in the moth suppression work, great areas of white pine could have been saved. Our present treatment, therefore, with white pine stands is simply to thin out the growth upon which the gypsy moth naturally feeds, such as oak and gray birch, and the stand is thereafter self-protecting.

To work out a policy whereby all of the various conditions and methods could be made to harmonize and still acccomplish results has been no small undertaking.

The earlier moth work entailed great expense and this in itself rendered it unpopular. The constant aim at present is to conduct the work along self-supporting lines as far as possible. In forestry methods of moth control, estimates of costs are made and the forest products practically sold before the operation is begun. The State Forester and his assistants supervise the work, let contracts for the milling, chopping, hauling, etc., but the owner advances the funds for the undertaking.

During the past three years approximately 45,000 cords of wood and between 7,000,000 and 8,000,000 feet of lumber have been operated under this plan.

Every time an operation of this sort is properly done, it is not only an example of good moth-suppression work, but a beginning of better forestry practice; the territory for future infestation is lessened by just that much, and, best of all, it is self-supporting. Any one can spend money in this work, but it takes men with experience and ability to break even or, still better, return a profit to the owner.

To find a market, or utilization alone, has been a perplexing problem. It has been necessary actually to create a market for our products. The wood-using industries had well-established sources of supply, and many ingenious plans were attempted before the trade could be interested. Three years ago, under very unfavorable markets, the work was made a success, and since the European war, of course, the only difficulty to surmount is that of getting efficient labor. The demand for forest products is far beyond our ability to supply.

Word has been sent out recently from the Massachusetts State Forester, through his local town officials and by means of the press, to all farmers and woodland owners, emphasizing the fact that this year offers exceptional opportunities for doing

constructive forestry work. The price of coal is very high, and, should present conditions continue, even more direful need for fuel may exist another season. At any rate everything is favorable for the better solving of our moth troubles and establishing permanent forestry conditions.

This whole subject is discussed more fully in the publications of the Massachusetts State Forester, which are available to those interested. I trust I have pointed out that utilization, particularly in our fight in the moth-constrol work in Massachusetts, has been a very practical method of attack. This work will necessarily need to be continued for years.

If the gypsy and brown-tail moths have done nothing else, they have driven us to a stern realization that we need to practice more and better methods of forestry management if we are to get best results.

Chestnut Blight

The disease known as the chestnut blight has swept over the northeastern part of the United States, and apparently stands ready to annihilate the chestnut tree in this section. It is common to Massachusetts generally, although in some sections of the state conditions are worse than in others. As the disease is communicable from tree to tree and is very virulent, the outcome is entirely problematic.

As is the case with moth work, Massachusetts is giving all possible aid to chestnut tree owners in utilization of their products, and at the same time is determining upon some forestry policy for the cut-over land. Where the chestnut is in mixtures of pine, the pine is retained with the idea of supplanting the chestnut growth with this species. Chestnut poles, ties and saw timber are all in demand at good prices; hence conditions are very favorable for owners to realize on this crop.

White Pine Blister Rust

This disease has been introduced into this country on nursery stock of either the white pine or other five-leaved pines, or on the currants and gooseberries, the plants belonging to the genus *Ribes*.

Unlike the chestnut bark disease it does not spread from pine to pine, but must alternate from pine to *Ribes* to complete its life cycle.

The disease is common in Europe and was found in New York state on imported stock several years ago. At that time, upon the invitation of Mr. J. S. Whipple, then forest, fish and game commissioner of New York, a conference of officials from various states and the government met at Albany and later in New York city, where the whole matter was fully discussed. The result of these meetings was to cease importing foreign white pine stock, rigidly inspect all future imports, grow our own stock in this country, and practice a close inspection of all foreign stock already planted here with a view to destroying it should the disease appear.

Recognizing the importance of having an inspection of the foreign stock already planted in Massachusetts, the State Forester had an official representative of the Bureau of Plant Industry of the United States Department of Agriculture visit our plantations and advise us regarding them in 1911.

Last year the disease was found on two of our large private estates, one in the eastern or North Shore section, and the other in the western or popular Berkshire country. Upon finding these outbreaks, interest was aroused in determining more fully the conditions elsewhere. It was found that the currants proved a good index for determining the presence of the disease, and an inspection over a considerable portion of the state showed its presence. Believing it of sufficient importance to make even further investigation in order to determine more fully to just what extent the disease may be found and to eradicate its evils, the state appropriated $10,000 for use the past season. The United States Congress also appropriated $50,000 for similar use throughout the Nation.

Scouting investigations have continued throughout the year and practically the whole state of Massachusetts has been covered. It is understood that the disease is found very generally distributed over the state, being, however, more commonly found in some sections than in others.

White pines are far less affected than are currants, but

here and there the pines are found with the disease. In no case, as far as the writer is aware, is there an infection of sufficient magnitude to destroy a stand of white pine of any appreciable size. Here and there, where the disease has been present for a period of years, a few fairly good sized trees, ranging up to 12 inches in diameter, contained more or less blister rust cankers on their branches and some upon the upper main trunk. in most cases here, however, the trees themselves were growing in abnormal conditions and were equally unhealthy from an unfavorable environment, and were infested with all the other disease and insect enemies common to their kind.

In plantations of imported stock the disease is likely to be found, and in our younger plantations, if the disease is present, it is in all likelihood accounted for in this way. Plantations of native stock are practically free from the disease. There is a possible danger, however, from these native plantations having been filled in with foreign stock, which might account for some infestations.

Our Massachusetts plantations of foreign stock have been gone over each year, and the infected trees have been pulled and burned. This practice, now running over a period of six years, has resulted in less and less infected trees each year, and at no time has the percentage of trees affected been as large as 1 per cent.

With our present knowledge of the subject, what remains for us to do in the future? The writer is frank to say that it is his belief that more harm than good has been done by the unnecessary agitation in the publicity campaign so systematically carried on at great expense, exciting people over a subject about which enough is not yet known even by experts themselves. It is a very easy matter to tear down, but quite another to build up and accomplish something. For the past ten years we have been working hard in Massachusetts to encourage better forestry practices, and reforestation, particularly with white pine, has just gotten under headway. Our people are interested and enthusiastically co-operating. We have millions of trees in our nurseries ready to go out, and all at once under the guise of public-spirited co-operation, and before there has been sufficient

evidence, a campaign is set in motion to discourage and thwart all our laudable reforestation endeavors.

Realizing that the blister rust disease needs attention, and believing that it could be properly safeguarded by those who are made responsible for so doing, last year the following recommendation was made in the State Forester's annual report, and it is believed it will bear repeating now, as follows:

> The white pine blister rust, one of the diseases of the white pine, should be given due consideration at the hands of our various State officials, particularly the pathologist of the Agricultural Experiment Station and the State Nursery Inspector, in determining our conditions as regards this disease. Some definite policy of holding the disease in check, or exterminating it if possible, should be arrived at. It is believed that while this disease may become very destructive to our white pines, nevertheless the danger is not sufficient to discourage prospective planters of the white pine. It is not our purpose to minimize the importance of this disease, nor do we intend to lessen our endeavor to combat it. We do, however, believe it is a good policy not to over-exaggerate the question, and thus necessarily deter the constructive work of reforestation, until there is more convincing proof than is to be had at present that the disease is likely to become a great menace to white pine. It is to be hoped that the average Massachusetts citizen will go ahead planting white pine as enthusiastically as ever, leaving the problem of its protection from diseases and insects to be looked after by technically trained officials.

We certainly have not sufficient knowledge at the present time to determine how serious a menace confronts us in this disease. Investigation and experience will have to serve as a guide to future operations.

From a more or less careful study of conditions my personal recommendations in handling this disease for this coming year would be as follows:

1. Empower a state department with authority to regulate and control any and all diseased white pines and *Ribes* (currants and gooseberries), declaring them a public nuisance and to be dealt with in a similar manner to that in which gypsy moths are now controlled.

2. That a sufficient appropriation be made for carrying the work on as the exigencies of the occasion demand from year to year.

Results are what is desired, and the sooner this disease is gotten in hand the better. Meanwhile optimism rather than pessimism will the better aid in solving our forestry problems. Where there is a will there is a way, and Massachusetts does not concede for one minute that we are going to lose our white pines, from any diagnosis that her State Forester, at least, can make thus far.

IS THERE A VARIATION IN THE TOXICITY OF COTTONSEED MEALS?

By W. A. WITHERS and F. E. CARRUTH
North Carolina Experiment Station

It seems quite probable that some cottonseed meals are more toxic than others. This is not due to a variation in the gossypol content of different varieties, but is due to different methods of manufacture in different mills and to varying the conditions of treating the seed in the same mill.

There is evidence that the amount of gossypol which passes into the crude oil varies considerably. Very little is present in crude oil from hot pressing, but much may be present in the "cold-pressed" oil from the Anderson Expeller.

Our experiments with rats show a great diminution in toxicity of cottonseed kernels after cooking under oil-mill conditions. This is due to a change of the gossypol to a less toxic form.

The authors have fed various meals to rats and have found considerable differences in the toxicity. Also a cottonseed meal which apparently had no action on rats was found toxic to rabbits.

PAPERS PRESENTED AT THE MEETING BUT NOT PRINTED HERE

The Mineral Metabolism of the Milch Cow—
E. B. Forbes, Worcester, Ohio.

Varying Effects of Salt on Different Plant Families—
S. M. Tracy, Biloxi, Miss.

The Farmer's Knowledge of the Details of His Business—
W. J. Spillman, Washington, D. C.

MEMORIAL TO WILLIAM RANE LAZENBY

By HERBERT OSBORN
Ohio State University

In the death of Professor Wm. Rane Lazenby, which occurred on September 15th, this Society has lost one of its most devoted members and a host of friends join with us in mourning his loss.

Professor Lazenby joined the Society in 1883 and, except for five surviving members, had been connected with the Society longer than any other member. He served as Secretary for the years 1886-1891 and as President from 1895 to 1897. In all his relations to the Society he showed the same qualities of good judgment, of constant method and firm adherence to high ideals that characterized his work in other connections.

It is especially fitting that the Society should now, at its first regular meeting since his death, pay its tribute to his character.

Professor Lazenby was born in Bellona, New York, December 5, 1850, and passed his boyhood days in country life but was ambitious for an education and with hard work earned his way through Cornell University, where his ability was early recognized and where he was given a position immediately after his graduation in 1874. His connection at Cornell continued until his election to the chair in the Department of Botany and Horticulture at the Ohio State University in 1881, a connection which continued until his death, although his relationship changed from that of Professor of Botany and Horticulture to that of Horticulture and Forestry in 1892, and to Professor of Forestry in 1910. He was also the first Director of the Ohio Experiment Station and largely responsible for its organization and early policies. In his university connection he has always been a strong force standing for the best in scientific education, with every practical emphasis upon the applications of science to agriculture and industry. His counsels in the university faculty, in the college faculty and in the special committees upon which he served exerted a great

influence in the shaping of the policies of the institution. Professor Lazenby maintained close connection with activities in the state and city, and especially in his connection with the State Horticultural Society, the Columbus Horticultural Society, the Ohio Academy of Science and the Ohio Forestry Society he was an active and faithful member.

Outside of the state he was associated with the American Association for the Advancement of Science, in which he was a Fellow, and frequently served in Sections and on the Council of the Association. He was also a member of the American Pomological Society and various other organizations devoted to horticulture and forestry.

Professor Lazenby had taken advantage of opportunities for foreign travel, had traveled extensively in America and showed the culture and breadth of association with people of various nationalities, creeds and culture. He was also a devoted member of the civic societies, especially the order of Masons, in which he had attained the thirty-third degree.

His scientific writings are scattered through the volumes of the Proceedings of the Ohio Academy of Science, Columbus Horticultural Society, the Ohio State Horticultural Society and the Ohio Biological Survey. In all his papers his work has shown a distinct trend toward the direct application of his discoveries to practical use.

He was a very faithful friend to students, assisting them in many ways in their efforts in securing an education, was a kind advisor and trusted friend and a man of helpful influence to an unusually large circle of acquaintances.

THE SCIENTIFIC WORK OF JOSEPH HOEING KASTLE

By ARTHUR S. LOEVENHART
Madison, Wis.

I have been requested to present an account of the scientific labors of Dr. Joseph Hoeing Kastle to the Society.

As you are all informed, Professor Kastle's death came very suddenly and unexpectedly on September 24th. Professor Kastle died at the age of 52 years. He published just one hundred scientific communications covering a very wide range of chemistry. [1]There is, at least, one very interesting contribution in each of these papers, as Kastle never wrote anything which was not well worth careful reading and study. These contributions cover almost every field of chemistry. As nearly as they can be classified they are distributed as follows:

Inorganic chemistry	7
Analytical chemistry	8
Soil chemistry	3
Organic chemistry	11
Photochemistry	2
Physical chemistry	19
Physiological chemistry	38
New Lecture Table Demonstrations	3
Miscellaneous	9
	100

Professor Kastle received his early training under Dr. Robert Peter, who first inspired Professor Kastle to enter the field of chemistry. From 1884-1888 Kastle spent in post graduate work at Johns Hopkins University and it was here that he absorbed the enthusiasm for original investigation and independent thought. During his last year at Hopkins he was a Fellow in chemistry.

From 1888 to 1905 Kastle was Professor of Chemistry at the State College of Kentucky. During this period of seven-

[1] Posthumous papers are still appearing in the journals.

teen years, without any other help than that of a single student assistant, he taught chemistry to an average of two hundred students a year, giving three to four lectures every day and laboratory work in elementary chemistry, analytical chemistry, organic chemistry and physical chemistry. He also directed the research work of the advanced students. His lecture courses included metallurgy and the history of chemistry. Laboring under these conditions in a small, poorly equipped laboratory for seventeen years he made fifty-one contributions to the literature of chemistry. From 1905 to 1909 he was Chief of the Bureau of Chemistry, Hygienic Laboratory, United States Public Health and Marine Hospital Service. From 1909 to 1911 he was Professor of Chemistry at the University of Virginia. In 1911 he was called to the Experiment Station, Kentucky State University, as Research Professor of Chemistry, which chair he occupied for one year when he became Director of the Experiment Station, succeeding Professor M. A. Scovell.

As a teacher Kastle had few equals. His teaching was truly of the inspirational type and fortunate indeed were the men who had the privilege of working with him. He saw that each man who took special work in chemistry made the most of what talent he possessed. All of his advanced students did some original investigation. The theses in his department for the degree of Bachelor of Science were the joint work of Kastle and the student. The majority were published and in many instances equalled the average thesis for a Doctor's degree. Kastle won the love and affection of his students for all time. Undoubtedly the wide range of Kastle's researches was due to the fact that he was forced to teach almost every phase of chemistry during the first seventeen years of his career. It was impossible for Kastle to come into intimate contact with scientific material and to handle it in his teaching without seeing problems to be solved. He taught every phase of the great science with the authority of a contributor to its annals of accomplishment. Kastle's lecture table demonstrations were always carefully prepared and he endeavored to illustrate every important and fundamental proposition by experiments. He contributed three articles on lecture table demonstrations, namely:

"On the Preparation of Hydrobromic and Hydriodic Acid." (Kastle and Bullock)

"Note on the Experimental Illustration of the Law of Multiple Proportions."

"On the Experimental Illustration of the Law of Definite Proportions through Combinations of the Halogens with Finely Divided Silver."

Another characteristic of Kastle as an investigator was his indomitable energy to drive his work to a conclusion. Without attempting at this time a complete review of Kastle's scientific work, I shall refer briefly to some of his contributions. Kastle always had a great interest in the subject of allotropism and we find four communications on this subject.

The work of Kastle and Kelley on the "Rate of Crystallization of Plastic Sulphur" is a valuable contribution to the subject of Allotropism. By a study of the color changes in sulphur, its solubility in carbon bisulphide, the effect of the medium and temperature on the rate of crystallization, they conclude that in plastic sulphur there are not one but several molecular species. The work of Kastle and Clark and of Kastle and Reed on the "Effect of Various Solvents on the Allotropic Change of Mercuric Iodide" and "On the Nature of Mercuric Iodide in Solution" are both splendid contributions to the subject of Allotropism.

In 1899 Kastle and W. A. Beatty studied by colorimetric methods the "Dissociation of Phosphorus Pentabromide in Solution in Organic Solvents," and demonstrated a remarkable difference between its dissociation in carbon tetrachloride and in carbon bisulphide. The following year Kastle and L. O. Beatty proved that the supposed red allotropic form of phosphorus pentabromide is in reality phosphorus heptabromide.

Kastle and W. A. Beatty studied:

(1) "The Effect of Light on the Displacement of Bromine and Iodine from Organic Bromides and Iodides."

(2) "The Effect of Light on the Combination of Hydrogen and Bromine at High Temperatures."

In connection with the work on photochemistry might be mentioned the work of Kastle and McDermott on the production

of light by the firefly. They studied the effect of the vapors of the following substances on the production of light by the firefly: air, oxygen, water, hydrogen, carbon dioxide, carbon monoxide, chlorine, nitrous oxide, nitric oxide, nitrogen teroxide, ammonia, hydrogen sulphide, sulphur dioxide, carbon bisulphide, cyanogen, hydrocyanic acid, cyanogen iodide, hydrofluoric acid, ether, chloroform, carbon tetrachloride, ethyl chloride, ethyl bromide, bromoform, iodoform, ethylene bromide, ethyl alcohol, methyl alcohol, amyl alcohol, allyl alcohol, acetone, formaldehyde, acetylene, benzene, petroleum, phenol, otho-cresol, paracresol, amyl nitrite, mononitrobenzene, essential oils, etc. They devised a method for keeping the luminous material active in the form of a dry powder for more than a year so that on moistening the material and exposing it to the air or to oxygen it became luminous. They demonstrated that in addition to the luminous substance, water and oxygen are required for the production of light.

Kastle was trained primarily as an organic chemist, thus his thesis presented for the degree of Doctor of Philosophy was on "Paranitrosulphobenzoic Acid and Some of Its Derivatives." This very interesting thesis led Kastle into some of his most important work which will be discussed later.

Kastle and Hill prepared a periodide by the action of Benzenesulphonic acid on potassium iodide which they believed to belong to a new class of organic periodides.

Kastle and Keiser prepared Diazobenzene Aniline Chloride by the action of nitrosyl chloride on aniline chloride. This compound they showed to be a double salt of diazobenzene chloride and aniline hydrochloride.

Kastle, Keiser and Bradley studied the Halogen Derivatives of the Sulphonamides in the course of which they studied two classes of derivatives, the sulphondichloramides and sulphondibromamides. In 1902 Kastle published the accumulated results of several years on a rather exhaustive study of tribromphenol bromide carried out with Loevenhart, Speyer and Gilbert. This included the preparation and properties of the substance, its decomposition under the influence of heat and light, its reaction with water, potassium iodide and zinc ethyl, the interesting acceleration of its spontaneous decomposition by

bromine vapor, its constitution, the preparation and properties of Tribrombenzene sulphonate, the conversion of tribromphenol bromide into metadibromquinone and the mechanism of the very interesting molecular rearrangement of tribromphenol bromide by means of sulphuric acid.

In 1911 Kastle again returned to the study of this interesting rearrangement and showed that Benbenesulphone dibromamide when treated with concentrated sulphuric acid undergoes the analogous rearrangement yielding dibrombenzenesulphonamide.

In the field of physical chemistry Kastle published four papers on the affinities of acids as follows: "The Taste and Affinity of Acids," "Cyanogen Iodide as an Indicator for Acids" (with Mary E. Clark), "On the Determination of the Affinities of Acids Colorimetrically by Potassium Dichromate" (with B. C. Keiser), "A Method for the Determination of the Affinities of Acids Colorimerically by Means of Certain Vegetable Coloring Matters."

Kastle published two very interesting communications on the color of compounds of bromine and of iodine. He shows that the red or yellow color of many of the organic and inorganic compounds of bromine and iodine are not constitutive properties of these compounds but are due to dissociation in the solid state whereby a small amount of the halogen is present in a free state and exhibits merely its own characteristic color. He showed that by heating these compounds their colors deepen until finally the substance is decomposed in quantity and the halogens escape. Then he demonstrated that at the temperature of liquid air (—190°C.) these substances are either much lighter in color or become entirely colorless. He marshals these facts and many other, all of which tend to show that the color of many compounds of bromine and iodine, such as iodoform, phosphorus pentabromide and heptabromide, tripromphenalbromide, mercuric iodide, lead iodide and many others, owe their color to dissociation of these substances in the solid state.

A great deal of work was done in Kastle's laboratory on oxidations. He first became interested in hydrogen peroxide as an oxidizing agent and Kastle and Loevenhart studied quantitatively the oxidation of formaldehyde by hydrogen peroxide

determining the effect of temperature, light and reaction on the velocity of the oxidation. Similarly Kastle and Smith studied the oxidation of sulphocyanic acid by hydrogen peroxide. Kastle and Clark studied the "Decomposition of Hydrogen Peroxide by Various Substances at High Temperatures." It was in this paper that Kastle first presented his view in very tentative form that in the catalysis of hydrogen peroxide the substance inducing the catalysis enters into combination with the hydrogen peroxide to form an unstable intermediate product which then breaks down yielding oxygen and water with the regeneration of the catalyser.

In 1903 Kastle published two papers with Loevenhart on the Mechanism of the Catalysis of Hydrogen Peroxide by Metals, Salts and Extracts of Living Tissues.

The previous year Kastle and Loevenhart published an article on "The Nature of Certain of the Oxidizing Ferments" in which they concluded that certain of the oxidizing ferments, at least, seem to be produced by whole molecules of oxygen being taken up by reducing substances present in living tissue to form organic peroxides which then act as strong oxidizing agents. According to this conception it seems probable that certain of the oxidizing ferments are not catalytic agents.

In 1901 Kastle and Shedd proposed the use of phenolphthalin as a reagent for the oxidizing ferments. This constitutes an important contribution to the subject of reagents for the oxidizing enzymes. In 1906 Kastle and Amoss used this reagent in studying the "Variation in the Peroxidase Activity of the Blood in Health and Disease."

In 1909 Kastle published a valuable article on the "Chemical Tests for Blood" and in 1910 he published his remarkably fine monograph on "The Oxidases."

Kastle's contributions to the subject of the mechanism of hydrolytic processes are probably as important as his contributions to the subject of oxidation. In the course of his thesis he prepared several esters of para-nitro-othosulphobenzoic acid and studied their hydrolysis.

In 1896 appeared the article by Kastle and Murrill, "On the Saponification of the Ethers of the Sulphonic Acids by Alcohol," and in 1897, "The Decomposition of Sulphonic

Ethers by Water, Acids and Salts," by Kastle, Murrill and Frazer. The results of these investigations formed the basis of the communication "Catalysis," by Kastle and Frazer, presented at the forty-seventh meeting of the American Association for the Advancement of Science, in Boston, August, 1898. Although this was one of the most important of Kastle's papers it was never published in full; only an abstract appeared in the Proceedings. In it, Kastle and Frazer developed a theory of hydrolytic processes which in its main features has been widely accepted. In 1900 Kastle and Loevenhart's communication "Concerning Lipase, the Fat-Splitting Enzyme and the Reversibility of Its Action" appeared. Here the fact was established that lipase not only accelerates the hydrolysis of esters but also brings about their hydrosynthesis from acid and alcohol. They also studied the stability of various preparations of lipase and the effect of many substances on the activity of this enzyme. It was in this connection that the remarkable inhibiting effect of the soluble fluorides on the activity of lipase was discovered. In 1902 Kastle made the interesting observation that the alkali salts of the acid esters of the aliphatic series are not hydrolyzed by lipase. In 1904 Kastle, Johnston and Elvove made a detailed study of "The Hydrolysis of Ethyl Butyrate by Lipase."

In 1906 Kastle studied the "Toxicity of Ozone and Other Oxidizing Agents to Lipase," and "The Influence of Chemical Constitution on the Lipolytic Hydrolysis of Ethereal Salts."

In 1908 Kastle published his work "On the Available Alkali in the Ash of Human and Cows' Milk in Its Relation to Infant Nutrition." In this important contribution Kastle pointed out that the mineral constituents and available alkali of cows' milk are relatively poorer than in human milk, a defect which could be corrected by dilution with water and skimmed milk and the addition of the necessary mineral substances. The soundness of Kastle's work and conclusions in this connection is now generally recognized by nutritional experts.

In 1915 Buckner, Nollau and Kastle published their work on "The Feeding of Young Chicks on Grain Mixtures of High and Low Lysine Content" in which it was shown that below a certain minimum of Lysine in the protein food stuffs, proper growth and development cannct occur.

Within the last few years have appeared a series of papers by Kastle and Healy on the following related subjects:

1912: "Parturient Paresis and Eclampsia."
"The Toxic Character of the Colostrum in Parturient Paresis."
"The Internal Secretion of the Mammae as a Factor in the Onset of Labor."
"Calcium Salts and the Onset of Labor."
1913: "The Pathology of Parturient Paresis"

These very interesting contributions are so recent that it is not possible to state at present exactly what role they will play in the clearing up of these immensely important subjects. As was pointed out in the beginning, I have not touched upon many of Professor Kastle's contributions. This is not a complete review of his work. Enough has been said, however, to indicate that America has lost one of its most eminent scientific men.

In closing, a word about Professor Kastle's personality may not be amiss in this review of his scientific labors. Professor Kastle's character was without a blemish. He showed a scrupulous desire to be fair in all scientific as well as personal matters. Any help he received in his scientific labors was always gratefully acknowledged when the results were published. Doctor Kastle was true to every relation of life. All who came under the spell of his charming personality feel deeply the irreparable character of their personal loss.

MEMBERSHIP OF THE SOCIETY

Honorary Member

1899 Hon. James Wilson, LL.D., *Traer, Iowa.*

Regular Members

(Arranged Alphabetically.)

The prefixed date is the year of election.

1907 Edwin West Allen, B. S. (Mass. Agri. Coll. and Boston Univ., '85), Ph. D. (Gottingen, '90); *U. S. Dept. Agri., Washington, D. C.;* Asst. Chem. Mass. Expt. Sta., '85-'88; Asst. Office Ext. Stas., '90-'93; Asst. Dir., do., '93—; Ed. Expt. Sta. Record, '95—.

1913 Harry Orson Allison, B. S. (Univ. Ill., '06), M. S. (do., '06); *Columbia, Mo.;* Instr. and Asst. in Anim. Husb., Univ. Ill., and Expt. Sta., '06-'10; Asst. Prof. Anim. Husb., Univ. Mo., '10-'12; Assoc. Prof., do., and Anim. Husb. Mo. Expt. Sta., '12—.

1913 John W. Ames, B. S. (Case School Appl. Sci., '98), M. S. (do, '06); *Wooster, Ohio;* Chem., Ohio Expt. Sta., '99—.

1889 Henry Prentiss Armsby, B. S. (Worcester Poly. Inst., '71), Ph. B. (Sheffield Sci. School, '74), Ph. D. (Yale Univ., '79), LL. D. (Univ. Wis., '04); *State College, Pa.;* Chem. Conn. Expt. Sta., '77-'81; Vice Prin. Storr Agr. School, '81-'83; Prof. Agr. Chem., Univ. Wis., '83-'87; Dir. Pa. Expt. Sta., '87-'07; Dean School of Agri., Penn. State College, '95-02; Dir. Inst. Animal Nutrition, '07—.

1886 Joseph Charles Arthur, B. S. (Iowa State Coll., '72), M. S. (do., '77), D. Sc. (Cornell Univ., '86); *Lafayette, Ind.;* Instr. Biol., Iowa State Coll., '76-'78; Instr. Bot., Univ. Wis., '79-'81; do., Univ. Minn., '82; Bot. N. Y. Expt. Sta., '84-'87; Prof. Bot., Purdue Univ., '87-'88; Prof. Veg. Phys. and Path., do., and Bot., Ind. Expt. Sta., '88-'15; Prof. Emeritus Bot., Purdue Univ., '15.

1906 Liberty Hyde Bailey, B. S. (Mich. Agr. Coll., '82), M. S. (do., '85), LL. D. (Univ. Wis., '07); *Ithaca, N. Y.;* Prof. Hort. and Landscape Gardening, Mich. Agr. Coll., '84-'88; Prof. Hort., Cornell Univ., '88-'03; Dir. Coll. Agr. and Expt. Sta., Cornell Univ., '03-'13; Editor and Writer, '13—.

1914 Elmer Darwin Ball, B. S. (Iowa St. Coll., '95); M. S. (do., '98), Ph. D. (Ohio State Univ., '07); *Logan, Utah;* Asst. in Zool. and Ent., Iowa St. Coll., '95-'97; Asst. in Zool. and Ento., Colo. Agr. Coll., '97-'02; Prof. Zool. and Ento., Utah Agr. Coll., 02-'07; Dean School Agr. and Dir. Expt. Sta., Utah Agr. Coll., '07—.

1879 WILLIAM JAMES BEAL, A. B. (Univ. Mich., '59), A. M. (do., '63), Sc. B. (Harvard Univ., '65), Sc. M. (Univ. Chicago, '75), Ph. D. (Univ. Mich., '80), D. Sc. (Mich. Agr. Coll., '05); *Amherst, Mass.;* Prof. Bot., Mich. Agr. Coll., '70-'72; Prof. Bot. and Hort., '72-'81; Prof. Bot. and Forestry, '81-'03; Prof. Bot., '03-'10; Prof. Emeritus, '10—.

1916 ORVILLE ANDREW BEATH, B. A. (Univ. Wis., '08); M. S. (do., '12), Instr. H. S. Science; Instr. Chem., Univ. of Kans., '12-'14; Asst. Chem., U. S. Forest Products Lab., '14; Research Chem., Univ. Wyo., '14—.

1912 AUGUSTINE WILBERFORCE BLAIR, B. S. (Haverford, '92), A. M. (do., '96); *New Brunswick, N. J.;* Prof. Chem., Guilford Coll., '96-'97; Asst. Chem., N. C. Expt. Sta., '97-'98; State Chem., N. C., '98-'99; Asst. Chem., Fla. Expt. Sta. and Univ. Fla., '99-'06; Chem., Fla. Expt. Sta., '06-'12; Assoc. Soil Chem., N. J. Expt. Sta., '12—.

1913—MAURICE ADIN BLAKE, B. S. (Mass. Agr. Coll., '04; *New Brunswick, N. J.;* Asst. Hort., R. I. Agr. Coll. and Expt. Sta., '04-'05; Instr. Hort., Mass. Agr. Coll., '05-'06; Hort., N. J. Expt. Stas., '06—.

1893 HENRY LUKE BOLLEY, B. S. (Purdue Univ., '88), M. S. (do., '89); *Agricultural College, N. Dak.;* Instr. Biol. and Asst. Bot. to Expt. Sta., Purdue Univ., '90; Prof. Bot. and Plant Path., N. Dak Agr. Coll. and Bot. and Plant Path. of Expt. Sta., do., '90—.

1909 WILLIAM PENN BROOKS, B. Sc. (Mass. Agr. Coll., '75), Ph. D. (Halle, '97); *Amherst, Mass.;* Prof. Agr. Imp. Coll. Agr., Sapporo, Japan, '77-'88; Prof. Bot., do., '81-'88; Pres., do., *ad interim* '80-'83 and '86-'87; Prof. Agr. and Agr., Mass. Agr. Coll. and Expt. Sta., '89-'09; acting Pres. and Dir., do., '05-'06; Dir. Expt. Sta., '06—.

1901 EDGAR ALLEN BURNETT, B. S (Mich. Agr. Coll., '87); D. Sc. (do., '17); *Lincoln, Nebr.;* Asst. Mich. Agr. Coll., '89-'93; Prof. Anim. Husb., S. Dak. Agr. Coll., '96-'99; Prof. Anim. Husb., Univ. Nebr., '99-'07; Dir. Nebr. Expt. Sta., '01—; Dean Coll. Agr., '09—.

1908 KENYON L. BUTTERFIELD, B. S. (Mich. Agr. Coll., '91), A. M. (Univ. Mich., '02); *Amherst, Mass.;* Supt. Mich. Farmers' Institutes, '95-'99; Instr. Univ. Mich., '02; Pres. Rhode Island Coll., '03-'06; Pres. Mass. Agr. Coll. and Head Div. Rural Sociol., '06—.

1909 FRANK KENNETH CAMERON, A. B. (Johns Hopkins, '91), Ph. D. (do., '94); *Washington, D. C.;* Fellow Cornell, '94-'95; Assoc. Prof., Catholic Univ., '95-'97; Asst. Physical Chem., Cornell, '97-'98; Expert, U. S. D. A., '98-'99; Soil Chemist, do., '99—.

1914 IRA DETRICK CARDIFF, B. S. (Knox Coll., 99); Grad. Stud. Univ. of Chicago, '02-'04; Ph. D. (Columbia Univ., '06); *Pullman, Wash.*, Asst. in Bot., Columbia Univ., '04-'06; Asst. Prof. of Bot., Univ. of Utah, '06-'07; Prof. of Bot., do., '07-'08; do. Washburn Coll., '08-'12; do. Univ. of Kans., '12; Prof. of Plant Physiol. and Bact., State Coll. of Wash., 1913; Dir., State Expt. Sta., State Coll. of Wash., '13—.

1908 MARK ALFRED CARLETON, B. S. (Kans. Agr. Coll., '87), M. S. (do., '93); *Washington, D. C.;* Asst. Bot., Kans. Expt. Sta., '92-'93; Cerealist, Bur. Plant Indus., U. S. D. A., '94-'12; Gen. Mgr., Penn. Chestnut Tree Blight Com., '12-'13; Cerealist, Bur. Plant Indus., U. S. D. A., '13—.

1915 WILLIAM L. CARLYLE, B. S. (Ontario Agr. Coll., '92), M. S. (Colo. Coll., '05); *Stillwater, Okla.*, in chg. Dairy School, Ontario, '93; Lect. Dairy and Live Stock, Minn. Farm Insts., '93-'97; Prof. Anim. Husb., Univ. of Wis., '97-'03; Prof. of Agr., Colo. Coll. and Dean Coll. of Agr, '04-'08; Genl. Secy. A. J. Knollin Co., Denver, Colo., '08-'10; Dir. Idaho Expt. Sta., '10-'14; Dir. Okla Expt. Sta., '14—.

1905 LOUIS GEORGE CARPENTER, B. S. (Mich. Agr. Coll., '79), M. S. (do., '84), Asst. Prof., Mich. Agr. Coll., '85-'88; Irr. Eng., Col. Agr. Coll. and Expt. Sta., '88-'10; Dir. Expt. Sta., do., '99-'10; State Eng., '03-'05; Consulting Irrigation Engineer, Denver, Colo., '10—.

1901 LOUIS ADELBERT CLINTON, B. S. (Mich. Agr. Coll., '89), M. S. (do., '97); *U. S. Dept. Agr., Washington, D. C.;* Asst. to Dir. Mich. Expt. Sta., '89-'93; Asst. Prof. Agr., Clemson Coll., '93-'95; Asst. Agr., Cornell Expt. Sta., '95-'02; Dir. Storris Expt. Sta. and Prof. Agr., Conn. Agr. Coll., '02-'12; Agriculturist, Bur. Plant Indus., '12-'15; Asst. Chief, Office of Extension Work, North and West, U. S. D. A., '15—.

1910—JOHN WALDO CONNAWAY, D. V. S. (Chicago Vet. Coll., '90), M. D. (Univ. Mo., '91); *Columbia, Mo.;* Prof. Physiology, Univ. Mo., '91-'97; Vet. Expt. Sta., do., '97-'00; Prof. Compar. Med. and Vet. to Expt. Sta., Univ. Mo., '00—.

1915 THOMAS COOPER, B. S. of A. (Minn. Coll. of Agri., '08); *Fargo, N. Dak.;* Spec. Agt. Bureau of Statistics, '04-'10; Statistical Agt. and Asst., Minn. Expt. Sta., '04-'08; Asst. Agriculturist, Univ. of Minn., '08-'10; Asst. Agriculturist in chg. Farm Mgmt., '10-'11; Dir. Better Farming Assn. of N. Dak.; '11-'14; Dir. Agrl. Expt. Sta. and Dir. Agrl. Ext., N. Dak. Agrl. Coll., '14—.

1910 LEE CLEVELAND CORBETT, B. S. (Cornell Univ., '90), M. S. (do., '96); *Washington, D. C.;* Asst. Hort., Cornell Univ., '91-'93; Prof. Hort. and Forestry, S. Dak. Coll., '93-'95; do.,

Univ. W. Va. and Expt. Sta., '95-'01; Hort., U. S. Dept. Agr., '01-'13; Asst. Chief Bur. Plant Indus., do., '13-'14; Hort., do., 14—.

1914 ARTHUR BURTON CORDLEY, B. S. (Mich. Agr. Coll., '88), M. S (do., '01); *Corvallis, Ore.;* grad. student, Cornell Univ., '00-'07; Asst. in Ento., Mich. Agr. Coll., '88-'90; Asst. Ento. Vt. Expt Sta., '90-'91; Asst. Ento., U. S. D. A., '91-'93; Prof. Zool. and Ento. Expt. Sta., Ore. Agr. Coll., '95-'12; Dean, School of Agr., do., '07—; Dir. of Expt. Sta., do., '14—.

1902—CHARLES FRANCIS CURTISS, B. S. A. (Iowa State Coll., '87), M. S. A. (do., '93), D. Sc. (Mich. Agr. Coll., '07; *Ames, Iowa;* Asst. Dir. Iowa Expt. Sta., '91-'97; Prof. Agr. and Acting Dir., Iowa Expt. Sta., '97-'00; Prof. Agr. and Dir., do., '00-'02; Dean and Dir., '02—.

1911 WILLIAM HADDOCK DALRYMPLE, M. R. C. V. S. England, '86; *Baton Rouge, La.;* Prof. Vet. Sci., La. State Univ., '89—; Vet., La. Expt. Sta., '89—.

1906 EUGENE DAVENPORT, B. S. (Mich. Agr. Coll., '78), M. S. (do., '81), M. Agr. (do., '95), LL. D. (do., '07); *Urbana, Ill.;* Prof. Agr., Mich. Agr. Coll., '89-'90; Dir. Coll. of Agr. Piracicaba, Brazil, '91-'92; Dean Coll. of Agr., Univ., Ill., '95—; Dir. Agr. Expt. Sta., '96—; Dir. Agr. Ext., '14—.

1913 ROBERT JOHN H. DELOACH, A. B. (Univ. Ga., '98), A. M. (do., '06); *Experiment, Ga.;* Bot., Ga. Expt. Sta., '06-'08; Prof. Cotton Indus., Univ. Ga., '08-'13; Dir., Ga. Expt. Sta., '13—.

1911 WILLIAM RUFUS DODSON, B. S. (Univ. Mo., '90), A. B. (Harvard Univ., '94); *Baton Rouge, La.;* Asst. Biol., Univ. Mo., '90-'93; Prof. Bot., La. Univ., '94-'02; Asst. Dir., La. Expt. Stas., '02-'05; Dir., do., '05—; Dean, Coll. Agr., La. Univ., '09—.

1910 JOHN FREDERICK DUGGAR, B. S. (Miss. Agr. Coll., '87), M. S. (do., '88); *Auburn, Ala.;* Asst. in Agr., Tex. Agr. Coll., '87-'89; Asst. Dir., S. C. Expt. Sta., '90-'92; Agr. Editor Office Expt. Stas., U. S. D. A., '93-'95; Prof. Agr., Ala. Poly. Inst., '96—; Dir. Ala. Expt. Sta., '03—.

1913 CLARENCE HENRY ECKLES, B. S. A. (Iowa State Coll., '95), M. S. (do., '97); *Columbia, Mo.;* Instr. and Asst. in Dairying, Iowa Coll. and Expt. Sta., '96-'01; Asst. Prof. Dairy Husb. Univ. Mo., and Dairyman Mo. Expt. Sta., '01-'06; Prof. and Dairyman, do., '06—.

1899 DAVID GRANDISON FAIRCHILD, B. S. (Kans. State Coll., '88), M. S. (do., '93); *Washington, D. C.;* Naples Zool. Sta., '93; Breslau and Berlin, '94; Bonn, '95; Buitenzorg Botanic Gardens, '96; Asst. Path. U. S. Dept. Agr., '89-'92; Special Agt. in charge Seed and Plant Production, '97-'98; Agr. Explorer, '98-'03; in charge Foreign Seed and Plant Introduction, U. S. Dept. Agr., '03—.

1880 William Gibson Farlow, A. B. (Harvard Univ., '66), M. D. (do., '70), LL. D. (do., '96; Univ. Glasgow, '01; Univ. Wis., '04); 24 *Quincy St., Cambridge, Mass.;* Asst. Prof. Bot., Harvard Univ., '74-'79; Prof. Cryptg. Bot., do., '79—.

1890 Bernhard Edward Fernow (Munden Forest Acad. Grad., '73), LL. D. (Univ. Wis., '97; Queen's, '03); *Toronto, Can.;* Chief, Div. Forestry, U. S. Dept. Agr., '86-'98; Dir. N. Y. State Coll. of Forestry, '98-'03; Lecturer Yale Forestry School, '04; Prof. of Forestry, Univ. of Toronto, '07—.

1911 Martin Luther Fisher, B. S. (Purdue Univ., '03), M. S. (Univ. Wis., '11); *Lafayette, Ind.;* Asst. in Agr., Purdue Univ., '03-'04; Instr. Agr., do., '04-'06; Asst. Prof. Agron., do., '06-08; Assoc. Prof. Agron., do., '08-'10; Prof. Crop Prod., do., '10—; Asst. Agr., Indiana Expt. Sta., '03-'10; Assoc. in Crops, do., '10—.

1910 Ernest Browning Forbes, B. Sc. (Univ. Ill., '97), B. S. Agr. (do., '02), Ph. D. (Univ. Mo., '08); *Wooster, Ohio;* Zool. Asst., Ill. Biol. Sta., '94-'96; Asst. to State Ento. of Minn., '97-'98; Acting State Ento. Minn., '01; Asst. in Anim. Husb., Ill. Expt. Sta., '01-'02; Instr. Anim. Husb., Univ. Ill., '02-'03; Asst. Prof. Anim. Husb., Univ. Mo., '03-'07; Chief in Nutr., Ohio Expt. Sta., 07—.

1908 Stephen Alfred Forbes, Ph. D. (Ind. Univ., '84), LL. D. (Univ. Ill., '05), *Urbana, Ill.;* Prof. Zool., Univ. Ill., '84-'09; State Ento. Ill., '82—; Dir. Ill. State Lab. of Nat. Hist., '77—; Dean Coll. of Sci., Univ. of Ill., '88—.

1916 Julius Herman Frandsen, B. S. A. (Iowa State Agr. Coll., '02), M. S. (do., '04), Asst.. Chem. Iowa Expt. Sta., '04-'06; Com'l dairy work, Portland, Ore., '06-'09; Prof. Dairy Husb., Moscow, Ida., '09-'11; Prof. Dairy Husb., Univ. of Nebr., Lincoln, Nebr., '11—.

1911 George Stronach Fraps, B. S. (N. C. Agr. Coll., '96), Ph. D. (Johns Hopkins Univ., '99); *College Station, Tex.;* Asst. Prof. Chem., N. C. Agr. Coll., and Asst. Chem. in Expt. Sta., '99-'03; Asst. Chem., Tex. Expt. Sta., '03-'04; Assoc. Chem., do., '04-'05; Chem., do., '05—; Assoc. Prof. Chem., Tex. Agr. Coll., '03-'05; Acting Prof., do., '05-'06; Assoc. Prof. Agr. Chem., do., '06—; State Chem., '06.

1888 William Frear, A. B. (Bucknell Univ., '81), Ph. D. (Ill. Wesleyan Univ., '83); *State College, Pa.;* Asst. Sci., Bucknell Univ., '81-'83; Asst. Chem., U. S. Dept. Agr., '83-'85; Prof. Agr. Chem., Pa. State Coll., '85—; Vice Dir. and Chem., Pa. Expt. Sta., '87—.

1913 Jons August Fries, B. S. (Pa. State Coll., '99), M. S. (do., '06); *State College, Pa.;* Asst. Chem., Pa. Expt. Sta., '89-'98; Expert Asst. Anim. Nutr., do., '98-'08; Asst. Dir. Inst. Anim, Nutr., '08—.

1908 Beverly Thomas Galloway, B. S. (Univ. Mo., '84), LL. D. (do., '02); *Ithaca, N. Y.;* Asst. Hort., Univ. Mo., '84-87; Asst. Path., U. S. Dept Agr., '87-88; Path. and Chief, Div. Veg. Path and Physiol., do., '88-'01; Chief Bur. Plant Indus., do., '01-'13; Asst. Sec. of Agr., '13-14; Dean N. Y. State Coll. of Agr. at Cornell Univ.; Dir. Cornell Univ. Agr. Expt. Sta and Agr. Ext., '14—.

1894 Harrison Garman, D. Sc. (St. Univ. of Kentucky); *Lexington, Ky.,* First Asst. State Lab. Nat. Hist., Ill., '83-'89; Asst. Prof. Zool., Univ. Ill., '85-'89; Ento. and Bot., Ky. Expt. Sta., '89—; State Ento., Ky. '97—; Prof. of Ento. and Zool., St. Univ. of Kentucky, '11—.

1894 Charles Christian Georgeson, B. S. (Mich. Agr. Coll., '78), M. S. (do., '82); *Sitka, Alaska;* Asst. Ed. of *Rural New Yorker,* '78-'80; Prof. Agr. and Hort., Tex. Agr. Coll., '80-'83; Prof. Agr. Coll. of Agr., Imperial Univ., Tokyo, Japan, '86-'89; Prof. Agr., Kans. State Agr. Coll., '90-'97; Special Agt. U. S. Dept. Agr., Dairy Industry, Denmark, '93; Asst. Agrostologist, U. S. Dept. Agr., '97-'98; Special Agt. in charge Alaska Expt. Sta., do., '98—.

1893 Clarence Preston Gillette, B. S. (Mich. Agr. Coll., '84), M. S. (do., '88); D. Sc. (do., '17); *Fort Collins, Colo.;* Asst. Zool., Mich. Agr. Coll., '87-'88; Ento. Iowa Expt. Sta., '88-'91; Prof. Zool. and Ento., Colo. Agr. Coll. and Ento. Expt. Sta., do., '91—; Dir. Expt. Sta., do., '10—; Colo. State Ento., —.

1911 Arthur Goss, B. S. (Purdue Univ., '88), M. S. (do., '95); *Lafayette, Ind.;* Asst. Chem., Ind. Expt. Sta., '88-'92; Asst., Ind. Weather Serv., '89-'92; Prof. Chem., N. Mex. Agr. Coll., and Chem. in Expt. Sta., '92-'03; Vice-Dir., N. Mex. Expt. Sta., '95-'00; Dir., Ind. Expt. Sta., '03—.

1916 Howard John Gramlich, B. S. (Univ. of Nebr., '11); Vice-Dir. Extension Work Nebr., '11-'13; Prof. Animal Husb., do., '13—.

1909 Harry Sands Grindley, B. S. (Univ. Ill., '88), Sc. D. (Harvard, '94); *Urbana, Ill.;* Asst. Chem., Univ. Ill., '88-'92; Asst. Chem., Harvard, '92-'93; Fellow Harvard, '93-'94; Instr. Chem., Univ. Ill., '94-'95; Asst. Prof. Chem., do., '95-'99; Assoc. Prof. Chem., do., '99-'04; Prof. and Dir. Chem. Lab., do., '04-'07; Prof. An. Chem., do., and Chief An. Chem., Expt. St., '07—.

1909 Theophilus L. Haecker, *University Farm, St. Paul, Minn.;* in charge Dairy Husb., Minn. Univ. and Expt. Sta., '92-'07; Prof. Dairy Husb. and Anim. Nutrition, do., '07-'09; Prof. Dairying, Anim. Husb. and Animal Nutrition, do., '10—.

1880 Byron David Halsted, B. S. (Mich. Agr. Coll., '71), M. S. (do., '74), Sc. D. (Harvard Univ., '78); *New Brunswick, N. J.;* Ed. *American Agriculturist,* '79-'85; Prof. Bot., Iowa State Coll.,

'85-'89; Prof. Bot. and Hort., Rutgers Coll., '89-'10; Bot., N. J. Expt. Sta., '89—.

1902 NIELS EBBENSEN HANSEN, B. S. (Iowa State Coll., '87), M. S. (do., '95); *Brookings, S. Dak.;* Asst. Prof. Hort., Iowa State Coll., '91-'95; Prof. Hort. and Forestry, S. Dak. Agr. Coll., and Hort., Expt. Sta., '95—.

1910 JOSEPH NELSON HARPER, B. S. (Miss. Agr. Coll., '95), M. A. (Ky. Agr. Coll., '06); *Clemson College, S. C.;* Dairy Husb., Miss. Expt. Sta., '95; Dairy Husb., Ky. Expt. Sta., '96-'98; Agriculturist, do., '98-'05; Dir. and Agron., S. C. Expt. Sta., '06—.

1910 BURT LAWS HARTWELL, B. S. (Mass. Agr. Coll. and Boston Univ., '89), M. S. (Mass. Agr. Coll., '00), Ph. D. (Univ. Pa., '03); *Kingston, R. I.;* Asst. Chem., Mass. Expt. Sta., '89-'91; Asst. Chem., R. I. Expt. Sta., '91-'03; Assoc. Chem., do., '03-'07; Chem., do., '07—; Prof. Agr. Chem., R. I. State Coll., '08—; Dir., R. I. Expt. Sta., '13—.

1905 WILLET MARTIN HAYS, B. Agr. (Iowa State Coll., '85), M. Agr. (do., '86); *Kennett Sq., Pa.;* Asst. Iowa Agr. Coll., '86; Assoc. Ed., *Prairie Farmer*, '87; Asst. in Agr., Iowa Agr. Coll., '88-'89; Prof. Agr. and Agrlst., Minn. Agr. Coll. and Expt. Sta., '90-'91; do., N. Dak Agr. Coll. and Expt. Sta., '92-'93; do., Minn. Agr. Coll. and Expt. Sta., '93-'04; Asst. Sec. of Agr., U. S. Dept. Agr., '04-'13; Farmer, 15—.

1911 HARRY HAYWARD, B. S. (Cornell Univ., '94), M. S. (do., '01); *Newark, Del.;* Asst. Prof. Dairy Husb., Pa. State Coll., '97-'02; Assoc. Prof. Anim. and Dairy Husb., N. H. Agr. Coll., '02-'03; Asst. Chief Dairy Div., U. S. Dept. Agr., '03; Dir. Agr. Dept, Mount Hermon School, '03-'06; Dean Agr. Dept., Del. Coll., and Dir. Del. Expt. Sta., '06—; Dir. Agrl. Ext., '14—.

1909 WILLIAM PARKER HEADDEN, A. B. (Dickinson, '72), A. M. (do., '75), Ph. D. (Univ. Giessen, '74); *Fort Collins, Colo.;* Asst., Univ. Pa., '74-'76; Prof. Chem., Md. Agr. Coll., '80-'84; do., Univ. Denver, '84-'89; do., S. Dak. School of Mines, '89-'91; Dean, do., '92-'93; Prof. Chem. and Geol., Colo. Agr. Coll., and Chem., Expt. Sta., '93—.

1909 ULYSSES PRENTISS HEDRICK, B. S. (Mich. Agr. Coll., '93), M. S (do., '95); *Geneva, N. Y.;* Asst. Hort., Mich. Agr. Coll., '93-'95; Prof. Bot. and Hort., Ore. Agr. Coll., and Hort., Expt. Sta., '95-'97; Prof. Bot. and Hort., and Hort., Expt. Sta., Utah, '97-'99; Prof. Hort., Mich. Agr. Coll., '99-'05; Hort., N. Y. Expt. Sta., '05—.

1905 JOSEPH LAWRENCE HILLS, B. S. (Mass. Agr. Coll. and Boston Univ., '81), D. Sc. (honorary, '03, Rutgers Coll.); *Burlington, Vt.;* Asst. Chem., Mass. Expt. Sta., '82-'83; Asst. Chem., N. J. Expt. Sta., '84-'85; Chem. Phos. Mining Co., Ltd., Beaufort,

S. C., '85-'88; Chem., Vt. Expt. Sta., '88-'98; Dir., do., '98—; Prof. Agr. Chem., Univ. Vt., '93—; Dean, Dept. Agr., do., '98—.

1889 LELAND OSSIAN HOWARD, B. S. (Cornell Univ., '77), M. S. (do., '86), Ph. D. (Georgetown Univ., '96); *Washington, D. C.;* Asst. Ento., U. S. Dept. Agr., '78-'94; Chief Ento., do., '94—; Perm. Sec., A. A. A. S., '98—.

1912 WALTER LAFAYETTE HOWARD, B. Agr., B. S. (Univ. Mo., '01), M. S. (do., '03) Ph. D. (Univ. Halle-Wittenberg, '06); *University Farm, Davis, Calif.;* Assist. in Hort., Univ. Mo.; '01-'03; Instr., do., '03-'04; Asst. Prof., do., '05-'08; Sec., Mo. State Board Hort., '08-'12; Prof. Hort., Univ. Mo., '08-'15; Assoc. Prof. Pomology, Univ. of Calif., '15—.

1903 THOMAS FORSYTH HUNT, B. S. (Univ. Ill., '84), M. S. (do., '92), D. Agr. (do., '04), D. Sc. (Mich. Agr. Coll., '07); *Berkeley, Cal.;* Asst. State Ento. of Ill., '85-'87; Asst. Agr., Univ. of Ill., '86-'88; Asst. Agr. Ill. Expt. Sta., '88-'91; Prof. Agr., Pa. State Coll., '91-'92; Prof. Agr., Ohio State Univ., '92-'95; Dean Coll. Agr., Ohio State Univ., '95-'03; Prof. Agron., Cornell Univ., and Agron., Expt. Sta., '03-'06; Dean Coll. Agr., and Dir. Agr. Expt. Sta., Pa. State Coll., '06-'12; Dean Coll. Agr., Univ. Cal., and Dir. Expt. Sta., '12—.

1908 WILLIAM DANIEL HURD, B. S. (Mich. Agr. Coll., '99) M. Agr. (do., '08); *Amherst, Mass.;* Instr., Lansing High School, '99-'01; Prof. Hort., Briarcliff Agr. School, '01-'03; Prof. Agri., Univ. Me., '03-'05; Acting Dean, Coll. of Agr., do., '05-'06; Dean, '06-'09; Dir. Agr. Ext., '09—.

1898 HENRY CLAY IRISH, B. S. (S. Dak. Agr. Coll., '91), M. S. (Iowa State Coll., '98); *Missouri Botanical Garden, St. Louis, Mo.;* Hort. Asst., Mo. Bot. Gard., '95-'02; Supt., do., '03-'12; Landscape Architect, '12-'13; Asst. Prof., Landscape Gard. and Flor., Iowa St. Coll., '13-'14; Supervisor, School Gardens, St. Louis, '14—.

1908 MYER EDWARD JAFFA, Ph. B. (Univ. Cal., '77), M. S. (do., '96); *Berkeley, Cal.;* Asst. Chem., U. S. Census, '79-'80; Asst. Agr. Dept., Univ. Cal., '80-'81; Asst. Chem., Northern Transcontinental Surv., '81-'83; Asst. Chem., Univ. Cal., '83-'96; Asst. Prof. Agr., do., '96-'06; do., Nutr., '06-'08; Prof. Nutr., do., '08—.

1885 EDWARD HOPKINS JENKINS, A. B. (Yale Univ., '72), Ph. D. (do., '79); *New Haven, Conn.;* Chem., Conn., Expt. Sta., '76-'00; Vice Dir., do., '82-'00; Dir., do., '00—; Treas., do., '01—; Dir. Storrs Expt. Sta., '12—.

1915 J. SHIRLEY JONES, B. S. (Univ. of Calif., '03; M. S. (Cornell Univ., '14); *Moscow, Idaho;* Asst. in Chem., Univ. of Calif., '02-'03; Asst. Chem. to Dr. H. E. Miller, San Francisco, '03-'04; Chem. for Giant Powder Co., San Jose, Calif., '05-'07; Chem.

Idaho Expt. Sta. and Prof. Agrl. Chem., Idaho St. Coll. of Agr., '07-'14; Dir. Idaho Expt. Sta., '14—.

1894 Whitman Howard Jordan, B. S. (Univ. Me., '75), M. S. (do., '79), D. Sc. (do., '96), LL. D. (Mich. Agr. Coll., '07); *Geneva, N. Y.;* Asst. Chem., Conn. Expt. Sta., '78-'79; Instr. Agr., Univ. Me., '79-'80; Prof. Agr. and Agr. Chem., Pa. State Coll., '81-'85; Dir., Me. Expt. Sta., '85-'96; Prof. Agr., Univ. Me., '94-'96; Dir., N. Y. Expt. Sta., '96—.

1912 John Chester Kendall, B. S. (N. H. Coll., '02); *Durham, N. H.;* Instr. in Dairy Husb., N. C. Agr. Coll., '02-'03; Asst. Prof. of Dairy Husb., do., '03-'06; State Dairy Comr., Kans., '06-'07; Prof. of Dairy Husb., Kans. Agr. Coll., '08-'10; Dir., N. H. Expt. Sta., '10—; Dir. Agr. Ext., '11—.

1916 Alvin Kezer, B. Sc. (Univ. of Nebr., '04), M. A. (do., '06); Special Agent B. P. I., '04-'06; Assoc. and Prof. of Soils, Univ. of Nebr., '06-'09; Prof. of Agronomy and Farm Manager, Colo. Agr. Coll., '09—.

1909 Benjamin Wesley Kilgore, B. S. (Miss. Agr. Coll., '88), M. S. (do., '90); *Raleigh, N. C.;* Asst. Chem., Miss. Agr. Coll., '88-'89; do., N. C. Expt. Sta., '89-'97; Prof. Chem., Miss. Agr. Coll. and Agr. Expt. Sta., '97-'99; State Chem., N. C., '99—; Dir., N. C. Expt. Sta., 01-'07; do., '13—.

1911—Henry Granger Knight, A. B. (Univ. Wash., Seattle, '02), A. M. (do., '04); *Laramie, Wyo.;* Asst. Chem., Univ. Wash., '00-'01; Instr., do., '01-'02; Asst. Chem., Univ. Chicago, '02-'03; Asst. Prof. Chem., Univ. Wash., '03-'04; Prof. Chem., Univ. Wyo., and State Chem., '04—; Dir., Wyo. Expt. Sta., '10—.

1916 E. J. Kraus, B. S. (Mich. Agr. Coll., '07); U. S. D. A. Bur. Ent., '07-'09; Ore. Agr. Expt. Sta., Prof. Research in Hort., '09—.

1889 Edin Fremont Ladd, B. Sc. (Univ. Me., '84); *Agricultural College, N. Dak.;* Asst. Chem., N. Y. State Expt. Sta., '84-'87; Chief Chem., do., '87-'90; Prof. Chem., N. Dak. Agr. Coll. and Chem. Expt. Sta., '90—; Food Comr. and State Chem., N. Dak., '00—.

1899 Joseph Bridgeo Lindsey, B. Sc. (Mass. Agr. Coll., '83), Ph. D. (Univ. Gottingen, '92); *Amherst, Mass.;* Asst. Chem., Mass. State Expt. Sta., '83-'85; Commercial Chem., '85-'89; Assoc. Chem., Mass. State Expt. Sta., '92-'95; Head Dept. Foods and Feeding, Hatch Expt. Sta., '95-'07; Chem., Mass. Expt. Sta., '07—; Vice Dir., do., '09—; Head Dept. Chem., Mass. Agr. Coll. and Goessmann Prof. of Agr. Chem., '11—.

1911 Frederick Bloomfield Linfield, B. S. A. (Ontario Agr. Coll, '91); *Bozeman, Mont.;* Asst. in Dairying, Ontario Agr. Coll, '92-'93; Prof. Anim. Indus. and Dairying, Utah Agr. Coll., '93-'02; Prof. Agr., Mont. Agr. Coll., '02—; Acting Dir., Mont. Expt. Sta., '03; Dir., do., '04—.

1912 Charles Bernard Lipman, B. Sc. (Rutgers Coll., '04), M. Sc. (do., '09), M. S. (Univ. Wis., '09), Ph. D. (Univ. Cal., '10); *Berkeley, Cal.;* Instr. in Soil Bact., Univ. Cal., '09-'10; Asst. Prof. Soils, do., '10-'12; Assoc. Prof. of Soils, do., and Soil Chem. and Bact., Cal. Expt. Sta., '12—.

1909 Jacob G. Lipman, B. Sc. (Rutgers, '98), A. M. (Cornell, '00), Ph. D. (do., '03); *New Brunswick, N. J.;* Asst. Chem., N. J. Expt. Sta., '98-'99; Fellow Chem., Cornell, '01; Soil Chem. and Bact., N. J. Expt. Sta., '01—; Asst. Prof. Agr., Rutgers, '06-07; Assoc. do., '07-'10; Prof. Soil Chem. and Bact., '10—; Dir. N. J. Expt. Stas., '11—.

1911 Charles Alfred Lory, B. Ped. (State Normal School, Greeley, Colo., '98), B. S. (Univ. Colo., '01), M. S. (do., '02), LL. D. do., '09); *Fort Collins, Colo.;* Asst. in Physics, Univ. Colo., '99-'02; Prin. Cripple Creek High School, '02-'04; Acting Prof. Physics, Univ. Colo., '04-'05; Prof. Physics and Elect. Engin., Colo. Agr. Coll., '07-'09; Pres., do., '09—.

1899 Robert Hills Loughridge, B. S. (Univ. Wis., '71), Ph. D. (do, '76); *Berkeley, Cal.;* Asst. Prof. Chem., Univ. Miss., '72-'74; Asst. State Geol., Miss., '72-'74; do., Ga., '74-'78; do., Ky., '82-'85; Prof. Agr. Chem., S. C. Coll., '85-'90; Asst. Prof. Agr. Chem. and Geol., Univ. Cal., '91-'08; Assoc. Prof., do., '08-'09; Emeritus Prof. Agr. Chem., do., '09—.

1911 Arthur Gillett McCall, B. S. Agr. (Ohio State Univ., '00); *Columbus, Ohio;* Asst., Bur. Soils, U. S. Dept. Agr., '00-'04; Asst. Prof. Agron., Ohio State Univ., '04-'05; Assoc. Prof. Agron., do., '05-'06; Prof. Agron., do., '06—.

1911 Charles Edward Marshall, Ph. B. (Univ. Mich., '95), Ph. D. (do., '02); *Amherst, Mass.;* Asst. Bact., Univ. Mich., '93-'96; do., Mich. Expt. Sta., '96-'98; Bact. and Hygienist, do., '98-'12; Sci. and Vice Dir., do., '08-'12; Prof. Bact. and Hyg., Mich. Agr. Coll., '03-'12; Dir. Graduate School and Prof. of Microbiol., Mass. Agr. Coll., '12—.

1911 Frederick Rupert Marshall, B. S. Agr. (Ontario Agr. Coll., '99), B. S. A. (Iowa State Coll., '00); *Washington, D. C.;* Asst. Prof. Anim. Husb., Iowa State Coll., '01-'03; Prof. Anim. Husb., Tex. Agr. Coll., '03-'07; Prof. Anim. Husb., Ohio State Univ., '07-'12; Prof. Anim. Indus., Univ. Cal., and Anim. Husb, Calif. Expt. Sta., '12-'13; Senior Anim. Husb., Bur. Anim. Indus., U. S. D. A., '13—.

1911 David William May, B. Agr. (Univ. Mo., '94), M. Agr. (do., '96); *Mayaguez, P. R.;* Asst. Agr., Missouri Expt. Sta., '97; Sci. Asst. Office Expt. Stas., U. S. D. A., '00-'02; Anim. Husb., Ky. Expt. Sta., '02-'04; Special Agt. in charge, P. R. Expt. Sta., '04—.

1905 Lucius Herbert Merrill, B. S. (Univ. Me., '83), D. Sc. (honorary, do., '08); *Orono, Me.;* Chem., Me. Expt. Sta., '86-'08; Prof. Biol. Chem., Univ. Me., '98-'07; Prof. Biol. and Agr. Chem., do., '07—.

1909 Merritt Finley Miller, B. S. Agr. (Ohio State Univ., '00), M. S. A. (Cornell Univ., '01); *Columbia, Mo.;* Asst. Bur. Soils, U. S. Dept. Agr., '01-'02; Instr. Agron., Ohio State Univ., '02-'03; Asst. Prof., do., '03-'04; Prof. Agron., and Agron., Univ. Mo. and Expt. Sta., '04—.

1916 George Edwin Morton, B. S. (Colo. Agr. Coll. '04, M. L. (Milton Coll., Wis., '04); Asst. and Prof. An. Husb., Univ. of Wyo., '04-'07; Prof. An. Husb. Colo. Agr. Coll., '07-'08; Head An. Husb. Dept., do., '08—; Colo. State Dairy Comnr., 13—.

1900 John Harcourt Alexander Morgan, B. S. A. (Univ. Toronto, '89); *Knoxvile, Tenn.;* Prof. Ento. and Hort., La. State Univ., '89-'93; Prof. Zool. and Ento., do., '93-'04; Ento., La. Expt. Stas., '89-'04; Dir. Gulf Biol. Sta., '99-'05; Dir. Tenn. Expt. Sta., '05—.

1911 Fred Winslow Morse, B. S. (Worcester, '87), M. S. (do., '00); *Amherst, Mass.;* Asst. Chem., Mass. Expt. Sta., '87-'88; do., N. H. Expt. Sta., '88-'89; Chem., do., '89-'09; Vice Dir., do., '96-'09; Prof. Chem., N. H. Agr. Coll., '90-'09; Research Chem., Mass. Expt. Sta., '10—.

1912 Warner Jackson Morse, B. S. (Univ. Vt., '98), M. S. (do., '03), Ph. D. (Univ. Wis., '12); *Orono, Me.;* Teach Nat. Sci., Montpelier Seminar, '99-'01; Asst. Bot., Vt. Expt. Sta., '01-'06; Instr. Bot., do., '01-'05; Asst. Prof. Bact., do., '05-'06; Plant Path, Me., Expt. Sta., '06—.

1909 Frederick Blackmar Mumford, B. S. (Mich. Agr. Coll., '91), M. S. (do., '93); *Columbia, Mo.;* Asst. Mich. Expt. Sta., '91-'95; Asst. Prof. Agr., Mich. Agr. Coll., '93-'95; Prof. Agr., Univ. Mo., '95-'04; Acting Dean Coll. Agr. Univ. Mo., and Acting Dir., Mo. Expt. Sta., '03-'05; Prof. Anim. Husb., Univ. Mo., '04—; in charge Anim. Husb. Dept., Mo. Expt. Sta., '06—; Dean Agr. and Dir. Expt. Sta., '09—.

1901 Herbert Windsor Mumford, B. S. (Mich. Agr. Coll., '91); *Urbana, Ill.;* Instr., Mich. Agr. Coll., and Asst., Expt. Sta., '95-'96; Asst. Prof. Agr. and Anim. Husb., do., '96-'99; Prof. Agr., do., '99-'01; Prof. Anim. Husb., Univ. Ill., and Chief in Anim. Husb., Ill. Expt. Sta., '01—.

1913 Martin Nelson, B. S. A. (Univ. Wis., '05), M. S. (do., '06); *Fayetteville, Ark.;* Adj. Prof. Field Crops and Soils Univ. Nebr. and Expt. Sta., '06-'07; Asst. Prof., do., '07-'08; Prof. Agron. and Agron., Univ. Ark. and Expt. Sta., '08-'13; Dean Univ. Ark. and Dir. Expt. Sta., '13—.

1893 HERBERT OSBORN, B. S. (Iowa State Coll., '79), M. S. (do., '80); *Columbus, Ohio;* Asst. Zool. and Ento., Iowa State Coll., '79-'83; Asst. Prof., do., '83-'85; Prof., do., '85-'98; Prof. Zool. and Ento., Ohio State Univ., '98—.

1893 LOUIS HERMAN PAMMEL, B. Agr. (Univ. Wis., '85), M. S. (do., '89), Ph. D. (Wash. Univ., '99); *Ames, Iowa;* Asst., Shaw School of Bot., '86-'89; Tex. Agr. Expt. Sta., '89; Prof. Bot., Iowa State Coll., '89—; Bot., Iowa Expt. Sta., '92—.

1893 HENRY JACOB PATTERSON, B. S. (Pa. State Coll., '86); *College Park, Md.;* Asst. Chem., Pa. Expt. Sta., '86-'88; Chem., Md. Expt. Sta., '88-'98; Dir. and Chem., do., '98; Pres. Md. Agr. Coll., '13—.

1910 RAYMOND PEARL, A. B. (Dartmouth Coll., '99), Ph. D. (Univ. Mich., '02); *Orono, Me.;* Asst. Zool., Univ. Mich., '99-'02; Instr. Zool., do., '02-'06; Instr. Zool., Univ. Penn., '06-'07; Biol. and Head Dept. Biol., Me. Expt. Sta., '07—; Assoc. Ed. *Zool. Jahresber,* '06-'08; *Biometrika,* '06-'10; *Zentbl. Alig. u Expt. Biol.,* '10—.

1909 RAYMOND ALLEN PEARSON, B. S. A. (Cornell Univ., '94), M. S. A. (do., '99); *Ames, Iowa;* Asst. Chief Dairy Div., U. S. Dept. Agr., '95-'02; Mgr. Walker-Gordon Lab. Co., N. Y. and Phila., '02-'03; Prof. Dairy Ind., Cornell Univ., '03-'07; N. Y. Comr. Agr., '07-'12; Pres. Iowa State Coll., '12—.

1910 WILLIAM ROBERT PERKINS, B. S. (Miss. Agr. Coll., '91); M. S. (do., '94); *Baton Rouge, La.;* Asst. State Chem., Miss., '91-'94; Chem., Miss. Expt. Sta., '94-'06; Asst. Prof. Agr., Miss. Agr. Coll., '06; Agron., Miss. Expt. Sta., '07-'10; Dir. Agr. Dept., and Prof. Agron., Clemson Coll., '10-'11; Supt. Syndicate Farm, Deeson, Miss., '11—.

1909 CHARLES VANCOUVER PIPER, B. S. (Univ. Wash., '85), M. S. (do., '92; Harvard, '00); *Washington, D. C.;* Prof. Ento., Wash. State Coll., '92-'93; Prof. Bot. and Zool., do., and Bot. and Ento., Expt. Sta., '93-'03; Syst. Agrostrologist, U. S. Dept. Agr, '03-'04; Agrostologist, do., '05—.

1890 CHARLES SUMNER PLUMB, B. S. (Mass. Agr. Coll., '82); *Columbus, Ohio;* Asst. Ed. *Rural New Yorker,* '83-'84; First Asst., N. Y. Expt. Sta., '84-'87; Prof. Agr., Univ. Tenn., and Asst. Dir., Expt. Sta., '87-'90; Prof. Agr. Sci., Purdue Univ., '90-'94; Prof. Anim. Indus. and Dairying, do., '94-'00; Prof. Anim. Indus., do., '00-'02; Vice Dir., Ind. Expt. Sta., '90-'91; Dir., do., '91-'02; Prof. Anim. Indus., Ohio State Univ., '02—.

1894 FRANK WILLIAM RANE, B. Agr. (Ohio State Univ., '91), M. Sc. (Cornell Univ., '92); *State House, Boston, Mass.;* Hort. and Microscopist, W. Va. Expt. Sta., '92-'95; Prof. Agr. and Hort, W. Va. Univ., '93-'95; Prof. Agr. and Hort., N. H. Coll., '95-'98; Prof. Hort., do., '98-'00; Prof. Forestry and Hort., do., '00-'06; State Forester, Mass., '06—.

1913 JAMES BURNESS RATHER, B. S. (Tex. Agr. Coll., '07), M. S. (do, '11), A. M. (Johns Hopkins Univ., '15); *Fayetteville, Ark.;* Asst. State Chem. Tex., '07-'09; Asst. Chem. Tex. Expt. Sta., '08-'12; First Asst. Chem., do., '12-'14; Prof. of Agr. Chem. and Chem. to Expt. Sta., Coll. of Agr., Univ. of Ark., '15—.

1913 GEORGE MATTHEW REED, A. B. (Geneva Coll., '00), A. M. (Univ. Wis., '04), Ph. D. (do., '07); *Columbia, Mo.;* Prof. Nat. Sci, Amity Coll., '00-'03; Asst. in Bot., Univ. Wis., '04-'07; Instr. in Bot., do., '07; Asst. Prof. Bot., Univ. Mo., '07-'12; Prof. Bot, do., '12—; Bot. Mo. Expt. Sta., '09—.

1881 ISAAC PHILLIPS ROBERTS, M. Agr. (Iowa State Coll., '75; 731 Cameron Avenue, *Fresno, Cal.;* Prof. Agr. and Dean Agr., Cornell Univ., '73-'94; Dir. Cornell Expt. Sta., '88-'03; Dir. Coll. Agr., '94-'03; Prof. Emeritus, lecturer and author, '03—.

1893 JAMES WILSON ROBERTSON, LL. D. (Toronto Univ., and Queen's Univ., '03; Univ. New Brunswick, '04); *Box 540, Ottawa, Can.;* Prof. Dairying, Ontario Agr. Coll., '86-'90; Dairy Comr. Canada, '90-'95; Comr. Agr. and Dairying, '95-'04; Prin., MacDonald Coll., '05-'09; Chairman Royal Com. on Indus. Training and Tech. Ed., '10—.

1909 PETER HENRY ROLFS, B. S., M. S. (Iowa State Coll., '91); *Gainesville, Fla.;* Asst. Bot., Iowa State Coll., '91; Ento. and Bot., Fla. Expt. Sta., '92-'98; Bot. and Hort., do., '98-'99; Bot. and Bact., S. C. Expt. Sta., '99-'01; Plant Path. in charge Sub-Trop. Lab., U. S. Dept. Agr., Miami, Fla., '01-'06; Dir., Fla. Expt. Sta., '06—; State Supt. Farmers' Institutes, '07—.

1911 GEORGE MCCULLOUGH ROMMEL, B. S. (Iowa Wesleyan Univ., '97), B. S. A. (Iowa State Coll., '99; *Washington, D. C.;* Expert in Anim. Husb., do., '05-'09; Chief, Anim. Husb. Div., do., '10—.

1909 HARRY LUMAN RUSSELL, B. S. (Univ. Wis., '88), M. S. (do, '90), Ph. D. (Johns Hopkins, '92); *Madison, Wis.;* Fellow Univ. Wis., '88-'90; Fellow Univ. Chicago, '92-'93; Asst. Prof. Bact., Univ. Wis., '93-'96; Prof. do., '96-'97; Bact., Wis. Expt. Sta., 93-'97; Dir. State Hygienic Lab., '03-'07; Dean Coll. of Agr. and Dir. Expt. Sta., Univ. Wis., '07—; Dir., Agr. Ext., '14—.

1912 WALTER GEORGE SACKETT, B. S. (Univ. Chicago, '02); *Fort Collins, Colo.;* Prof. Nat. Sci., Meredith Coll., '02-'04; Special Agt., U. S. Dept. Agr., '04; Instr. Bact. and Hyg., Mich. Agr. Coll., '04-'06; Asst. Prof. and Hyg., do., and Asst. Bact. Mich. Expt. Sta., '06-'08; Bact., Colo. Expt. Sta., '08—.

1908 EZRA DWIGHT SANDERSON, B. S. (Mich Agr. Coll., '97), B. S. Agr. (Cornell, '98); *Chicago, Ill.;* Asst. State Ento. Md., '98-'99; Ento., Del. Expt. Sta., and Assoc. Prof. Zool., Del. Coll., '99-'02; State Ento. Tex., and Prof. Ento., Tex. A. and M. Coll., '02-'04; Ento., N. H. Expt. Sta., and Prof Ento., and Zool. N. H. Coll,

'04-'09; Dir. N. H. Expt. Sta., '07-'09; Dean Coll. Agr., W. Va. Univ., '10-'15; Dir., W. Va. Expt. Sta., '12-'15; Student, Univ. Chi., '15—.

1910 Robert Sidney Shaw, B. S. (Ontario Agr. Coll., '93); *East Lansing, Mich.;* Asst. Agr., Mont. Agr. Coll. and Expt. Sta., '97-'02; Prof. Agr., Mich. Agr. Coll., '02-'08; Dean Agr., do., and Dir. Expt. Sta., '08—.

1893 Thomas Shaw, *2135 Knapp Street, St. Paul, Minn.;* Prof. Agr., Ontario Agr. Coll., '88-'93; Prof. Anim. Husb., Minn. Coll. Agr., '93-'03; Ed. *Farmer*, '03-'08; Northwest Ed. Orange Judd Publications, '08—.

1898 John Henry Shepperd, B. Agr. (Iowa State Coll., '91), M. S. A. (Univ. Wis., '93); *Agricultural College, N. Dak.;* Ed. Staff *Orange Judd Farmer*, '93; Prof. Agr., N. Dak. Agr. Coll., and Agriculturist Expt. Sta., '93-'04; Dean and Vice Dir., '04—.

1909 John Harrison Skinner, B. S. (Purdue Univ., '97); *Lafayette, Ind.;* Asst. Agr., Ind. Expt. Sta., '99-'01; Instr. Anim. Husb., Univ, Ill., '01-'02; Assoc. Prof. Anim. Husb., Purdue Univ., '02-'06; Prof., do., '06; Dean Agr. Dept., Purdue Univ., '07—.

1907 Clinton DeWitt Smith, M. S. (Cornell Univ., '75; *Trumansburg, N. Y.;* Dir. Ark. Expt. Sta., '90; Dir. Minn. Sta., and Prof. Dairy Husb., Univ. Minn., '90-'93; Dir. Mich. Expt. Sta. and Prof. Agr., '93-'08; Dir. and Dean Spec. Course, Mich. Agr. Coll., '99-'08; Dir. Escola Agricola Practica, Brazil, '08-'12; Farmer and Lecturer, '12—.

1907 Howard Remus Smith, B. Sc. (Mich. Agr. Coll., '95); *University Farm, St. Paul, Minn.;* Teach, Tilford Collegiate Acad. and Rock Island High School, '95-'09; Acting Prof. Agr., Univ. Mo., '00-'01; Asst. Prof. Anim. Husb., Univ. Nebr., '01; Assoc. Prof., do., '02; Prof., do., '03-'12; Anim. Husb., Univ. Minn., '12-'14.

1899 Harry Snyder, B. S. (Cornell Univ., '89); *1800 Summit Ave, Minneapolis, Min.;* Asst. Chem., Cornell Univ. Expt. Sta., '90-'91; Asst. Instr. Qual. Anal., do., '89-'90; Prof. Agr. Chem., Univ. Minn., and Chem., Expt. Sta., '91-'09; Chem., Russell Miller Milling Co., '09—.

1909 Andrew McNairn Soule, B. S. (Univ. Toronto, '93), Sc. D. (honorary, Univ. Ga., 10); *Athens, Ga.;* Asst. Dir., Mo. Expt. Sta., '94; Asst. Prof. Agr. and Asst. Agriculturist, Tex. Agr. Coll. and Expt. Sta., '94-'99; Dir. Tenn. Expt. Sta. and Chairman Agr. Faculty, Univ. Tenn., '99-'04; Dean of Agr. and Dir. Expt. Sta., Va. Poly. Inst., '04-'07; Pres. Coll. Agr. Univ. Ga., '07—.

1903 William Jasper Spillman, B. S. (Univ. Mo., '86), M. S. (do., '89), Sc. D. (do., '10); *Washington, D. C.;* Prof. Sci., Mo. State Normal, '87-'89; Prof. Sci., Vincennes Univ., '89-'91;

Prof. Sci., Ore. State Normal, '91-'94; Prof. Agr., State Coll. Wash., '94-'01; Agrostologist, U. S. Dept. Agr., '01-'04; Agriculturist in charge Farm Management, do., '04—.

1911 FRANK LINCOLN STEVENS, B. L. (Hobart, '91), B. S. (Rotgers Coll., '93), M. S. (do., '97); Ph. D. (Univ. Chicago, '00), *Urbana, Ill.;* Teacher of Sci. Racine Coll., '93-'94; do., Columbus, O., High School, '94-'97; Instr. in Biol., N. C. Agr. Coll., '00-'02; Prof. Bt. and Veg. Path., do., '03-'11; Biol., N. C. Expt. Sta., '03-'11; Dean, P. R. Coll. Agr., '12-'14; Prof. Plant Path., Univ. Ill., '14—.

1917 ROBERT STEWART, B. S. (Utah Agr. Coll., '02), Ph. D. (Univ. of Ill., '09); Prof. of Chem. and Asst. Dir. of Utah Agr. Expt. Sta., '08-'15; Assoc. Prof. Soils and Assoc. Chief in Soil Fertility, Expt. Sta., Univ. of Ill., '15—.

1908 WILLIAM ALTON TAYLOR, B. S. (Mich. Agr. Coll., '88), D. Sc. (do., '13); *Washington, D. C.;* Asst. Pomol., U. S. Dept. Agr., '91-'01; Pomol. in charge Field Investigations, '01-'10; Asst. Chief, Bur. Plant Indus., '11-'13; Chief, do., '13—.

1911 ROSCOE WILFRED THATCHER, B. Sc. (Univ. Nebr., '98), M. A. (do., '01); *University Farm, St. Paul, Minn.;* Asst. Chem., Nebr. Expt. Sta., '99-'01; Asst. Chem., Wash. Expt. Sta., '01-'03; Chem., do., '03-'12; Asst. Prof. Chem., State Coll. Wash., '04-'06; Assoc. Prof., do., '06-'10; Prof. Agr. Chem. and Head of Dept. Agr., do., '10-'13; Dir. Wash. Expt. Sta., '07-'13; Prof. Agr. Chem. and Agr. Chem., Univ. Minn. and Expt. Sta., '13—.

1907 CHARLES EMBREE THORNE, M. Agr. (Ohio State Univ., '90); *Wooster, Ohio;* Dir. Ohio Expt. Sta., '87—.

1910 EDWARD GAIGE TITUS, B. S. (Colo. Agr. Coll., '99); M. S. (do., '01), D. Sc. (Harvard, '11); *Logan, Utah;* Asst. Dept. Zool. and Ento., Colo. Agr. Coll., '00-'01; Field Asst. State Ento., Ill., '01-'03; Spec. Agt., Bur. Ento., U. S. Dept. Agr., '03-'07; Prof. Zool. and Ento., Utah Agr. Coll. and Ento., Expt. Sta., '07—.

1901 CHARLES ORRIN TOWNSEND, B. S. (Univ. Mich., '88), M. S. (do., '91), Ph. D. (Leipsic, '97); *Washington, D. C.;* Prof. St. Johns Coll., Md., '88-'91; Prof. Sci., Wesleyan Coll., Ga., '91-'95; Instr. Bot., Barnard Coll., '98; Prof. Bot., Md. Agr. Coll., and State Plant Path. Md., '98-'01; Path. Bur. Plant Indus., U. S. Dept. Agr., '01-'10; do., '12—; Consulting Agr., U. S. Sugar and Land Co., '10-'12.

1881 SAMUEL MILLS TRACY, B. A. (Mich. Agr. Coll., '68), M. S. (do., '76); *Biloxi, Miss.;* Asst. Prof. Agr., Mo. State Univ., '77-'80; Prof. Bot. and Hort., do., '80-'87; Dir. Miss. Expt. Sta., '87-'97; Spec. Agt. U. S. Dept. Agr., '97—.

1894 WILLIAM TRELEASE, B. S. (Cornell, '80), D. Sc. (Harvard, '84) LL. D. (Wis., '02; Mo., '03; Wash. Univ., '07); *Urbana, Ill.;* Prof. Bot. Univ. Wis., '83-'85; Engelmann Prof. Bot. and Dir. Shaw School Bot., Wash. Univ., '85—; Dir. Mo. Bot. Gard., '89-'12; Research Work, '12-'13; Prof. Bot., Univ. Ill., '13—.

1913 PERRY FOX TROWBRIDGE, B. Pd. (Mich. Norm. Coll., '92), Ph. B. (Univ. Mich., '92), A. M. (do., '05), Ph. D. (Univ. Ill., '06), M. Pd. (Mich. Norm. Coll., '11); *Columbia, Mo.;* Instr. Chem., Univ. Mich., '94-'02; Sugar Chem., do., '02-'05; Research Asst. and Instr. in Chem., Univ. Ill., '05-'07; Agr. Chem. and Assoc. Chem., Univ. Mo. and Expt. Sta., '07-'08; Prof. and Chem., do., '08—.

1907 ALFRED CHARLES TRUE, B. A. (Wesleyan Univ., Conn., '73), M. A. (do., '76), Ph. D. (Erskine Coll., S. C., '86), D. Sc. (Wesleyan Univ., '06); *Washington, D. C.;* Prin. High School Essex, N. Y., '73-'75; Instr. State Normal School, Westfield, Mass., '75-'82; Grad. Stud., Harvard Univ., '82-'84; Instr, Wesleyan Univ., 84-'88; Ed., U. S. Office Ext. Stas., '88-'91; Asst. Dir., do., '91-'93; Dir., do., '93-'14; Dir., States Relations Service, U. S. D. A., '14—.

1914 HUBERT EVERETT VAN NORMAN, B. S. (Mich. Agr. Coll., '97); *Davis, Calif.;* Mgr. Dairy Farm, '97-'98; Supt. Univ. Farm, Purdue Univ., '98-'02; Chief, Dairy Dept., Purdue Univ., '02-'05; Prof. Dairy Husb., Pa. St. Coll., '05-'13; Prof. Dairy Mgmt., Univ. of Calif., '13—; Vice Dir., Agr. Expt. Sta. and Dean, Univ. Farm School, '13—.

1908 ALFRED VIVIAN, Ph. G. (Univ. Wis., '94); *Columbus, Ohio;* Instr. Phar., Univ. Wis., '94-'95; Asst. Agr. Chem., do., '95-'97; Instr., do., and Asst. Chem., Expt. Sta., '97-'02; Assoc. Prof. Agr. Chem., Ohio State Univ., '02-'05; Prof. Agr. Chem., do., '05—.

1912 JOHN FRANCIS VOORHEES, B. S. A. (Univ. Tenn., '09), M. S. A. (do., '11); *Knoxville, Tenn.;* Asst. Observ., U. S. Weather Bur, New Orleans, La., '01; do., Knoxville, Tenn., '02-'05; Observ. in charge Knoxville Sta., '06—; Instr. in Met. and Consult Met., Univ. Tenn. and Expt. Sta., '09—.

1893—HENRY JACKSON WATERS, B. Agr. (Univ. Mo., '86); *Manhattan, Kans.;* Asst. Agr., Mo. Expt. Sta., '87-'91; Prof. Agr., Pa. State Coll., '92-'95; Dean Coll. Agr. and Dir. Expt. Sta., Univ. Mo., '96-'09; Pres. Kans. State Agr. Coll., '09—.

1914 RALPH LEVI WATTS, B. A. (Pa. State Coll., '90), M. S. (do., '99); *State College, Pa.;* Hort. of Tenn. Expt. Sta., '90-99; Lecturer, Farmers Institutes, Pa., Md., N. J., '99-'08; Prof. of Hort., Pa. St. Coll., '08-'12; Actg. Dean and Dir. School of Agr. and Expt. Sta., do., '12-'13; Dean and Dir., do., '13—.

1910 HERBERT JOHN WEBBER, B. Sc. (Univ. Nebr., '89); M. A. (do, '90), Ph. D. (Wash. Univ., St. Louis, '00); *Riverside, Cal.;* Asst. in Bot., Univ. Nebr., '89-'90; Asst., Shaw School of Bot., '90-'92; Physiol., U. S. Dept. Agr., '92-'97; in charge Plant Breeding Lab., do., '97-'07; Prof. Expt. Plant Breeding, Cornell Univ., '07-'12; Dir., Citrus Expt. Sta., and Dean, Grad. School Trop. Agr., Univ. Cal., '13—.

1896 JULIUS BUELL WEEMS, B. Sc. (Md. Agr. Coll., '88), Ph. D. (Clark Univ., '94); *South Boston, Va.;* Instr. Chem. and Math., Md. Agr. Coll., '88-'89; Con. Chem., do., '91-'92; Prof. Agr. Chem. and Chem. Expt. Sta., Iowa State Coll., '95-'04; Industrial Chem., '04—.

1904 HOMER JAY WHEELER, B. Sc. (Mass. Agr. Coll. and Boston Univ., '83), Ph. D. (Univ. Gottingen, '89), D. Sc. (Brown, '11); *92 State St., Boston., Mass.;* Asst. Chem., Mass. Expt. Sta., '83-'87; Chem., R. I. Expt. Sta., '89-'08; Prof. Geol., R. I. Coll., '89-'12; Prof. Agr. Chem., do., '03-'10; Acting Pres., do., '02-'03; Dir. Expt. Sta., do., '01-'12, Agron., do., '05-'12; Expert, Amer. Agr. Chem. Co., '12—.

1889 MILTON WHITNEY, *Washington, D. C.;* Asst. Chem., Conn. Expt. Sta., '83; Supt. Expt. Farm, N. C. Expt. Sta., '86-'88; Prof. Agr., S. C. Coll., and Vice Dir. Expt. Sta., '88-'91; Soil Physicist, Md. Expt. Sta., '91-'94; Prof. Soil Physics, Md. Agr. Coll., '94-'01; Chief Bur. Soils, U. S. Dept. Agr., '94—.

1898 JOHN CHARLES WHITTEN, B. S. (S. Dak. Agr. Coll., '91), M. S. (do., '99), Ph. D. (Univ. Halle, '02); *Columbia, Mo.;* Instr. in Hort. and Hort. Expt. Sta., S. Dak. Agr. Coll., '92; Asst. in Hort., Mo. Bot. Gard., '93-'94; Prof. Hort. and Hort. Expt. Sta., Univ. Mo., '94—.

1911 JOHN ANDREAS WIDTSOE, B. S. (Harvard Univ., '94), Ph. D. (Univ. Gottingen, '99); *Logan, Utah;* Chem., Utah Expt. Sta., '94-'05; Prof. Chem., Utah Agr. Coll., '95-'05; Dir. Utah Expt. Sta., '00-'05; Dir. School of Agr., Brigham Young Univ., '05-'07; Pres., Utah Agr. Coll., '07—.

1912 JULIUS TERRASS WILLARD, B. S. (Kans. Agr. Coll., '83), M. S (do., '86), D. Sc. (do., '08); *Manhattan, Kans.;* Asst. in Chem. Kans. Agr. Coll., '83-'87; Asst. Prof. Chem., do., '90-'96; Assoc. Prof. Chem., do., '96-'97; Prof. Appl. Chem., do., '97-'01; Prof. Chem., do., '01—; Dean, Div. Gen. Sci., do., '09—; Asst. Chem., Kans. Expt. Sta., '88-'97; Chem., do., '97—; Dir., do., '00-'06; Chem., Kans. Engin. Expt. Sta., '10—.

1912 CHARLES BURGESS WILLIAMS, B. S. (N. C. Agr. Coll., '93), M. S. (do., '96); *West Raleigh, N. C.;* Asst. Chem., N. C. Dept. Agr., '93-'06; Agron., do., '06-'07; Dir. and Agron., N. C. Expt. Sta., '07-'12; Vice Dir. and Agron., do., '13—.

1908 CARLOS GRANT WILLIAMS, *Wooster, Ohio;* Agron., Ohio Expt. Sta., '03—.

1911 WILLIAM ALPHONSO WITHERS, A. B. (Davidson Coll., '83), A. M. (do., '85); Grad. Stud. Cornell Univ., '88-'90; Fellow ib., '89-'90; *West Raleigh, N. C.;* Asst. Chem., N. C. Expt. Sta., '84-'88; Prof. Chem., N. C. Agr. Coll., '89—; Statis. Agt., U. S. Dept. Agr., '95-'02; Acting Dir., N. C. Expt. Sta., '97-'99; Chem., do., '97—.

1909 FRITZ WILHELM WOLL, B. S. (Royal Fredericks Univ., Christiana, '82), Ph. B. (do., '83), M. S. (Univ. Wis., '86), Ph. D (do., '04); *Davis, Calif.;* Asst. Chem., Wis. Expt. Sta., '87-'97; Chem., do., '97-'13; Asst. Prof. Agr. Chem., Univ. Wis., '93-'04; Assoc. Prof., do., '04-'06; Prof. do., '06-'13; Prof. Anim. Nutr., Univ. Cal. and Expt. Sta., '13—.

1903 ALBERT FREDERICK WOODS, B. Sc. (Univ. Nebr., '90), A. M. (do., '92), D. Agr. (do., '13); *University Farm, St. Paul, Minn.;* Asst. Bot., Univ. Nebr., '91-'94; Asst. Chief Div. Veg. Path., U. S. Dept. Agr., '94-'00; Chief, do., '01-'09; Asst. Chief, Bur. Plant Indus., do., '01-'09; Dean Coll. of Agr., Univ. Minn., and Dir. Expt. Sta., '10—.

1903 CHARLES DAYTON WOODS, B. S. (Wesleyan Univ., Conn., '80), D. Sc. (honorary, Univ. Me., '05); *Orono, Me.;* Asst. Chem., Wesleyan Univ., '80-'85; Instr. Sci., Wilbraham Acad., Mass., '83-'88; Chem., Conn. Storrs Expt. Sta., '88-'96; Vice Dir., do., '89-'96; Prof. Agr., Univ. Me., '86-'03; Dir. Maine Expt. Sta., '96—.

1916 DANIEL WEBSTER WORKING, B. S. (Kans. State Agr. Coll., '88), M. S. (Univ. of Denver, Colo., '07); Lecturer, Colo. State Grange, '90-'91 and '94-'95; Master Colo. State Grange, '92-'93; Secy. Colo. State Board of Agr. and Agr, Coll., '93-'97; County Supt. Schools of Arapahoe County, Colo., '05-'07; Supt. Agr. Exten. Work, W. Vir. Univ., '07-'11; Office Farm Mgmt. and Ext. Work in North and West, U. S. D. A., '11—.

1911 BONNEY YOUNGBLOOD, B. S. (Tex., Agr. Coll., '02, M. S. (do., '07); *College Station, Tex.;* Prin. and Instr. in Agr., Henderson, Tex., City Schools, '03-'05; Prin. and Instr. in Agr., Mineola, Tex., High School, '05-'06; Supt. City Schools and Instr. in Agr., Pauls Valley, Okla., '06-'07; Asst. Agr., Office of Farm Management, U. S. Dept. Agr., '07-'11; Dir., Tex. Expt. Sta., '11—.

1910 C. A. ZAVITZ, B. Sc. (Toronto Univ., '88); *Guelph, Canada;* Asst. Expt. Dept., Ontario Agr. Coll., '86-'93; Head of Expt. Dept., '93—; Prof. of Field Husbandry, Ontario Agr. Coll., '04—.

DECEASED MEMBERS

Robert Fairchild Kedzie,	Born Dec.	9, 1852	Died Feb.	13, 1882
Lauren Briggs Arnold,	" Aug.	13, 1814	" Mar.	7, 1888
George Hammel Cook,	" Jan.	5, 1818	" Sept.	22, 1889
Patrick Barry,	" May	24, 1816	" June	24, 1890
John J. Thomas,	" Jan.	8, 1818	" Feb.	22, 1895
Charles Valentine Riley,	" Sept.	18, 1843	" Sept.	14, 1895
Charles Lee Ingersoll,	" Nov.	1, 1844	" Dec.	15, 1895
Edward Louis Sturtevant,	" Jan.	23, 1842	" July	30, 1898
Sir John B. Lawes, *Hon. Mem.*,	" Dec.	28, 1814	" Aug.	31, 1900
John Alvah Myers,	" May	28, 1853	" April	8, 1901
Sir Henry Gilbert, *Hon. Mem.*,	" Aug.	1, 1817	" Dec.	23, 1901
Robert Clark Kedzie,	" Jan.	28, 1883	" Nov.	27, 1902
Victor Hunt Lowe,	" Sept.	23, 1869	" Aug.	27, 1903
Henry English Alvord,	" Mar.	11, 1844	" Oct.	1, 1905
Robert Warington, *Hon. Mem.*,	" Aug.	22, 1838	" Mar.	20, 1907
Willis Grant Johnson,	" July	4, 1866	" Mar.	11, 1908
James Fletcher,	" Mar.	28, 1852	" Nov.	8, 1908
Samuel William Johnson,	" July	3, 1830	" July	21, 1909
William Henry Brewer,	" Sept.	14, 1828	" Nov.	2, 1910
Charles Anthony Goessmann,	" June	13, 1827	" Sept.	1, 1910
Samuel B. Green,	" Sept.	15, 1859	" July	11, 1910
Welton M. Munson,	" April	8, 1866	" Sept.	9, 1910
Edward Burnett Voorhees,	" June	22, 1856	" June	6, 1911
Franklin Hiram King,	" June	8, 1848	" Aug.	4, 1911
Oskar Kellner, *Hon. Mem.*,	" May	13, 1851	" Sept.	22, 1911
John Bernhardt Smith,	" Nov.	21, 1858	" Mar.	12, 1912
Melville Amasa Scovell,	" Feb.	26, 1855	" Aug.	15, 1912
Charles Edwin Bessey,	" May	21, 1845	" Feb.	25, 1915
Eugene Waldemar Hilgard,	" Jan.	5, 1833	" Jan.	8, 1916
Joseph Hoeing Kastle,	" Jan.	25, 1864	" Sept.	24, 1916
William Rane Lazenby,	" Dec.	5, 1850	" Sept.	15. 1916

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PROCEEDINGS

OF THE

THIRTY-EIGHTH ANNUAL MEETING

OF THE

Society for the Promotion of Agricultural Science

WASHINGTON, D. C.,

November 12 and 13, 1917

EDITED BY THE SECRETARY

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President

HERBERT OSBORN............................Columbus, Ohio

Vice-President

R. W. THATCHER............................Madison, Wis.

Secretary-Treasurer

C. P. GILLETTE............................Fort Collins, Colo.

Custodian

W. D. HURD............................Amherst, Mass.

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DAVID FAIRCHILD............................Washington, D. C.
W. R. DODSON............................Baton Rouge, La.
C. D. WOODS............................Orono, Maine

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Term began		Expired
1880	W. J. Beal, *of Michigan*	1882
1881	W. H. Brewer, *of Connecticut*	1884
1884	H. E. Alvord, *of New York*	1886
1886	E. L. Sturtevant, *of New York*	1887
1887	R. C. Kedzie, *of Michigan*	1889
1889	C. E. Bessey, *of Nebraska*	1891
1891	I. P. Roberts, *of New York*	1893
1893	W. Saunders, *of Ontario, Canada*	1895
1895	W. R. Lazenby, *of Ohio*	1897
1897	B. D. Halsted, *of New Jersey*	1899
1899	W. J. Beal, *of Michigan*	1901
1901	W. H. Jordan, *of New York*	1903
1903	William Frear, *of Pennsylvania*	1905
1905	H. P. Armsby, *of Pennsylvania*	1907
1907	T. F. Hunt, *of Pennsylvania*	1909
1909	S. M. Tracy, *of Mississippi*	1911
1911	Eugene Davenport, *of Illinois*	1913
1913	H. J. Waters, *of Kansas*	1915
1915	Charles E. Thorne, *of Ohio*	1916
1916	Herbert Osborn, *of Ohio*	

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1880	E. L. Sturtevant, *of Massachusetts*	1882
1882	G. C. Caldwell, *of New York*	1883
1883	F. A. Gulley, *of Mississippi*	1885
1885	B. D. Halsted, *of Iowa*	1886
1886	W. R. Lazenby, *of Ohio*	1891
1891	L. O. Howard, *of District of Columbia*	1893
1893	W. Frear, *of Pennsylvania*	1895
1895	C. S. Plumb, *of Indiana*	1899
1899	T. F. Hunt, *of Ohio*	1900
1900	F. M. Webster, *of Illinois*	1905
1905	F. W. Rane, *of Massachusetts*	1910
1910	E. W. Allen, *of District of Columbia*	1914
1914	L. A. Clinton, *of District of Columbia*	1916
1916	C. P. Gillette, *of Colorado*	

MINUTES OF THE 38th ANNUAL MEETING OF THE SOCIETY FOR THE PROMOTION OF AGRICULTURAL SCIENCE

Held at Washington, D. C., November 12-13, 1917

The meeting was called to order by President Herbert Osborn.

The report of the Secretary-Treasurer was presented and referred to an auditing committee consisting of J. G. Lipman, M. F. Miller and E. B. Forbes.

On motion by W. D. Hurd, the Executive Committee was requested to work out the details for the joint membership of this society with other scientific societies contemplated by the resolution presented by the Executive Committee of this society last year and passed by a majority vote of the members, and report back at the next meeting.

The report of the Custodian, W. D. Hurd, was received and placed on file.

On motion by W. J. Beal, the Chair was instructed to appoint a committee of three on nominations. The committee was appointed as follows: W. J. Beal, E. A. Burnett and Thos. F. Hunt.

On motion by Martin Nelson, the Chair was instructed to appoint a committee of three on resolutions. The committee appointed consisted of C. B. Lipman, C. E. Thorne and A. G. McCall.

On motion by W. J. Beal, it was decided that hereafter the Secretary-Treasurer shall be paid a salary of $50.00 a year.

On motion by E. A. Burnett, the Treasurer was instructed to invest $200.00 of the society's surplus in Liberty Bonds of the next issue.

The Committee on Nominations reported as follows:

For President, Herbert Osborn, Columbus, Ohio.

For Vice-President, R. W. Thatcher, Madison, Wis.

For Secretary-Treasurer, C. P. Gillette, Fort Collins, Colorado.

For Custodian, W. D. Hurd, Amherst, Mass.

For member of the Executive Committee, David D. Fairchild, Washington, D. C.

On motion, the recommendations of the committee were unanimously adopted and the Secretary was instructed to cast the ballot of the society for the persons named.

The Auditing Committee reported that they found the accounts of the Treasurer correct and that there was a balance of $301.36 in the treasury.

The following resolutions were recommended by the Resolutions Committee and unanimously adopted:

"*Resolved*, That this Society is in complete accord with the Government of the United States in its efforts to assist the nations of Europe to resist the encroachments of a policy which aims at the overthrow of all democratic institutions. Be it further

"*Resolved*, that we pledge our undivided support to further in every way possible the increased production of the food which is necessary to the successful support of our allies and ourselves during the war."

"A minute adopted by the Senate of the University of California on the life work of the late Dr. Robert Hills Loughridge, has been transmitted to the Secretary of this society and we respectfully recommend that it be spread upon the minutes of this meeting and printed in the Proceedings of the Society." (See page 123.)

On motion the society adjourned to meet at the call of the Executive Committee.

C. P. Gillette, *Secretary.*

THE OUTLOOK IN AGRICULTURAL SCIENCE

PRESIDENTIAL ADDRESS

Herbert Osborn

It is quite safe to say that in the whole history of this society there has been no meeting when so many vital issues were coming to the front, no year which has seemed so momentous in the history of our science, our nation or the world. Under such circumstances it might seem very easy to select an appropriate topic for the purpose of this address, a function which stands as a mandate of the society.

But the very abundance of issues, the bewildering array of urgent and imperative steps in science and the rapidly changing points of view as well as the pressure of duties and distracting demands incident to the situation all combine to render a careful selection or a calm and judicious discussion a matter of difficulty. I am confident that your sympathy will tend to supply some of the deficiencies that exist and that are due, in part at least, to the unusual circumstances of the period.

It is clear that, in the momentous issues confronting us, agricultural problems take a most important place, so vital indeed, that they have been given a prominence never before accorded them, and the response has been beyond anything we know in history. It is fitting therefore to present briefly, and with confessed inadequacy, some thoughts on the future outlook of agricultural science.

It is to be assumed that the outcome of the present world struggle must eventually establish our present grip on a civilization that means growth of science and advancement of human welfare. No other expectation is tolerable to a world so largely committed to freedom of thought and action.

In the reconstruction which must follow the establishment of order who can doubt the tremendous influence of modern science and especially the sciences underlying the agricultural progress of the world. What, then, can agricultural science offer to the

successful accomplishment of the immediate task before us and later to the more attractive problem of constructive development of food production and the conditions vitally important not only to the agricultural communities but to the world's population as a whole.

Before attempting an answer may we look for a moment at some of the responses to be seen already. We have noted with much satisfaction the practically universal and immediate response of workers in science to the urgent appeal for scientific aid in the solution of national problems. I doubt if any other body of men have given more unselfishly of time and effort or of loyal support to the nation's needs. This is only as it should be, for perhaps no other body of men has had a larger help in its training and in the opportunities for development with national and state support or aid.

Perhaps even more gratifying is the fact that the assistance of the scientific worker is now so eagerly sought and generally used by the public. Witness the tremendous call for instruction in planting, protecting, harvesting and preserving all kinds of crops and the enormous increase reported in this line. Reports place the increase of products of the farm for the country at seven billions of dollars and the war gardens alone are credited with $350,000,000 worth of produce. Now how large a part of this increase may be credited to improved scientific methods of culture and crop protection it may be impossible to estimate. We need not stop for that estimate now, but if we allow only one-seventh of the gross estimate, or one billion dollars, we will have a result that pays for all the money expended on experiment stations and agricultural colleges in the past quarter century, or probably, the past half century, which means practically all so applied in this country.

Moreover, this increase is compared with figures already greatly increased by the use of scientific methods. A comparison of production from equal acreages for this year with that for a year, a quarter of a century ago, would be fairer and I have no doubt far more striking.

I do not mean to argue that all this expenditure must needs have been returned in money values. The greatest return for expenditure in research and education should always be in the

intellectually trained and intelligent body of citizens produced. But it is significant of our scientific progress and of the ability of research that when the emergency arose we had a body of trained, expert workers ready for the tasks imposed and a sufficiently established confidence on the part of the public to secure prompt and important results. Perhaps the most cheering view comes when we look beyond the present emergency and contemplate the tremendous advance that should follow when this training and public confidence may be applied to the furtherance of peaceful progress in all our arts and industries.

We may certainly hope that the experience of cultivators generally will have been so favorable that it will forever silence the cry against the scientific methods in agriculture and serve to convince a continually increasing body of citizens that acceptance of the results of modern science is the most certain road to practical improvement and an advanced agriculture.

ACHIEVEMENTS AND PROSPECTS.

In considering the achievements and prospects of those branches of science related to agriculture today, one is confronted with the fact that agricultural science now is a very different thing from what it was when this society was organized. In fact whole branches of science relating to agriculture have been born and developed in the past forty years.

I have a very distinct and personal recollection of my first contact with this organization a number of years before I was admitted to membership. It was at the Philadelphia meeting in 1884, when as a result of my association with Dr. Bessey, one of its founders, I happened to be present when a group of the early members were discussing plans and policies for the society. I recall especially besides Dr. Bessey, Dr. W. J. Beal, Dr. Dabney, Dr. Sturtevant, Dr. Jordan and Dr. Saunders. Most of these men I met then for the first time and I need not dwell upon the inspiration that the fortunate acquaintance with these pioneers in agricultural science was to a beginner, getting his first impressions of scientific leaders and scientific organization. It was by this means, I think, that I secured my strongest conviction that the ultimate goal of science should be the service of society and, as I look back upon the efforts of these men and others active with

them in directing the current of scientific activity along channels that would reach the needs of practical agriculture, I am the more impressed with the wisdom and foresight of their view. The promotion of science involves support and confidence from a wide circle, including many unacquainted with its methods, and a well founded confidence is secured only by such demonstration as will appeal to such a general circle.

But perhaps the most striking feature as I see it now, was the fact that this group of pioneers included only chemists and biologists. Moreover, in the first list of members, published for 1882, while a few are listed as professors of agriculture or as Directors of Experiment Stations, practically every man was known for his work in biology or chemistry. Now, Physics, Geology, Agricultural Engineering, Farm Economics and Sociology and Farm Management would be included in any broad classification of the sciences fundamental in farm production and rural life. Then too, the specialization and development of the lines in chemistry and biology have resulted in an almost bewildering array of related branches all standing as comspicuously as the old groups of Agricultural chemistry, Botany, Zoology and Entomology of the earlier days. Bacteriology, then hardly recognized as having any relation to soil or crops or even to dairy products, has assumed gigantic proportions with fully recognized importance to most fundamental factors of success in agriculture. Plant pathology and applied entomology have grown from practically new subjects to occupy commanding positions not only with scientific workers but with practical cultivators in all lines of agriculture.

Perhaps even more notable has been the development and application of branches of study scarcely counted as agricultural science a quarter century ago. Soil Physics, Farm Engineering Rural Economics and Home Economics with their problems of farm machinery, farm management, finance, marketing, home conditions and community life all represent applications of scientific principles to the problems of production and distribution with fundamental associations for the efficiency and welfare of the agricultural community. In so far as these subjects have been brought within the realm of scientific method of investigation they demand and are receiving the thoughtful and cordial recognition of all the workers in all branches of agricultural science. Hearty

co-operation and helpfulness is the attitude and watchword of all comrades in this worthy effort.

For a number of the branches of science now considered fundamental to the advancement of agriculture I do not feel qualified to speak with intelligence, but from casual notice of the problems which are being attacked and occasional contact with workers in the various fields it is very evident that all have their unsolved problems and that these give promise of most important advances not only for the particular branch involved but for many others, since we have learned most certainly that the advance of one branch of science is very often absolutely dependent upon the solution of some question in another branch.

One of the great strides as I see it has been made in the application of engineering science in agriculture or the development of farm engineering as an almost distinct branch of engineering. Man has for ages utilized some of the energy producing forces of nature but never before to so great an extent and never before, I take it, has there appeared so great an opportunity to draw still more extensively upon these primal forces for the benefit of industry. What may follow in the way of utilization of wind or water or more directly from the sun's energy and through the channels of gravity, electricity, heat, combustion or other forms of power no one can fully foresee, but we have gone far enough to assert with confidence that the work of the farm as well as that of the shop will be greatly changed and economized in future years.

The control of water for the purposes of drainage, irrigation, power and even the growth of distinctive aquatic crops in suitable area presents a most attractive field and the greater use of the wind, obscured at present by the cheapness of other sources of power, may take on new phases and assume new proportions when the need becomes more urgent. These with many others, including the perfection and invention of new machinery offer, it seems, abundant opportunity for the agricultural engineer and inventor.

The geological questions dealing with the derivation and content of soils; the physical problems of the soil and the atmosphere; the whole range of meteorological conditions affecting growth of crops and conditions of life; the multitudinous phases of chemical application in all kinds of agricultural work from composition of

soils to dairy products, from nutritive value of foods to formulæ for insecticides all bear their most necessary relation to present practice and no doubt offer unlimited opportunity for further investigation. I have not the time, even had I the knowledge, to forecast developments in these fields.

Within the newly developed branches of human relations the studies in rural economics, home economics, rural social conditions, the problems of distribution, marketing, farm labor, tenancy, farm credits, statistics, transportation, including the good roads question, rural mail and communication generally, there seems to one who has been a spectator rather than an active participant that the advances of the past decade must presage enormous development in the near future and that there is in these lines of investigation the opportunity for great service. It is perhaps permissible, considering the wonderful advance since the introduction of the automobile and the rapid strides in the conquest of the air, to see visions of such development in aeronautics as to provide weather signals, rural mail delivery, and express service which, coupled with the telephone, the wireless, and the trolley will provide the most extensive opportunity for communication of all kinds and do away with the isolated condition of farm life even for the localities more remote from centers of population. Already many of the disadvantages of rural isolation have been removed and we may expect the further contributions of various branches of science to add much in this direction.

A conspicuous example of the development of a new branch of work is illustrated in the subject of agronomy, the votaries of which have done us the honor to meet with us on this occasion. Agronomy, I take it, is not so much a separate branch of science as a selection of materials mainly from physics, chemistry and biology, which bear on the special problems of crop production. I speak with diffidence in this presence, especially as we are to hear later from first authority, what an agronomist is or at least what the agronomist of the future is to be. In any event, it is very evident from the activity of this society and the nature of the problems they are attacking that they have abundant opportunity for future effort.

Another field of recent rapid growth, of broad interest but essentially biologic in its materials and methods of study is

embraced under the general term of genetics. Plant and animal breeding have been subjects of study for centuries but the recent discoveries of basic principles of heredity have given a new impetus and a security of foundation that promises most important and much more rapid results. Not only are most important improvements to be looked for in the production of improved types or races of cultivated plants and domesticated animals but we may hope that the application of such principles may lead to social regulations and eugenic practices that will contribute to the elimination of the unfit in human society and the gradual betterment of the race.

Within the general biological field I have already hinted at the developments in bacteriology, and the open questions relating to soils, dairy products, diseases of man and domestic plants and animals and the hosts of forms which bear important relations to other organisms will presumably occupy the workers in this field for many years to come.

In the general botanical field questions of weed control, possible means of reducing injury by frost or low temperatures by control of physiological conditions, of the plant or content of the atmosphere, ecological studies of adaptation to soil topography, etc., seem open.

In the general realm of zoology there are, not to mention the various problems connected with animal nutrition, heredity, etc., included under the general groups of animal, husbandry, many problems of fundamental character. I may be pardoned for dwelling a little more fully upon certain subjects which appear to me to have much of promise to the future investigator. One of these may be referred to under the head of general parasitology. We are just beginning to realize how extensive a group of diseases of man and domestic animals are dependent upon protozoan parasites and the connection with different, often alternating, hosts. Mention of yellow fever, Texas fever of cattle or as now often called "tick fever" because of the transmitting agency, the spotted fever, malaria and a host of tropical fevers suffice to indicate their importance. How many more diseases that have baffled the doctor and veterinarian in the past will be traced to these sources we cannot say but we may confidently expect many others and the gain to human efficiency and happiness will be helped accordingly.

Then there are the parasitic worms, flukes, insects and other forms too numerous to mention that are still but imperfectly known.

We have also a large field of opportunity in the unutilized forms of life that there is every reason to believe may be brought into valuable service for man, the wild fur bearing animals which may be utilized in waste or broken hill and mountain country, the aquatic animals that thrive in swamps and ponds and streams and which only wait investigation of their possibilities to occupy their place in an economy which we can direct very largely to human interest.

In many of these studies it may be difficult to see the immediate economic goal but we may be certain that the definite facts acquired will, either directly or indirectly, in good time prove their value in the general scheme of useful knowledge.

In my own field of work in which I feel more competent to speak the progress of the past quarter century has been remarkable and the outlook for progressive activity inspiring. With many great achievements behind us we find ourselves today with larger opportunities, with an infinite number of questions pressing for solution and greater appreciation and demand on the part of the public than ever before.

These opportunities assume many different phases and extreme specialization of our field is one of the marked features of the day. This has gone so far indeed that it is almost impossible to keep abreast of the progress in all lines. It is no longer possible for a man to profess familiarity with entomology in all its branches. Aside from systematic and economic workers in the general sense we must have specialists in each group of insects and for many different phases of economic and biologic work. The man who handles fruit insects may have little to do with farm crop insects or the pests of live stock. This differentiation is well illustrated in our great National Bureau of Entomology with its many divisions each with its expert staff of specialists.

Further we have specialization in the matter of research, instruction and extension or demonstration all of which is necessary and useful for efficiency and progress. However, we must recognize the limitations that this specialization imposes on the individual worker and endeavor to guard against a too narrow view of too circumscribed horizon.

The specialist must know something of related and supporting branches of science in order to be able to draw from them the service necessary in his particular work and to co-operate effectively in the solution of problems having a complex of principles and requiring joint effort for their solution.

The control of an insect pest may require knowledge of its life history, its relation to certain plants, its adaptation to season, its natural enemies and also its relation to cultural methods, the mechanical devices for using insecticides, the chemical composition of poisons or insecticidal substances and the physical character of emulsion and other mixtures for successful application. Therefore the entomologist, who can scarcely ever be trained in all these lines, must know the sources and be able to assemble the various factors for the accomplishment of his end. Co-ordination and co-operation have become essential here as in many other enterprises.

PROMISING PROBLEMS

To mention briefly some of the more promising fields one may cite increasing interest in ecological study with all it offers concerning relation of insects to crops, the growing knowledge of predaceous and parasitic enemies which serve as checks on injurious forms; the great impetus to efforts to secure knowledge of menacing foreign species which it may still be possible to exclude, and the still open field in experiments on insecticide compounds and machinery.

While I have no doubt that direct methods for insect control will continue to occupy a large place in our investigations and entomological practice I believe that we will give increased attention to the utilization of natural checks by introduction or culture of beneficial forms, to the development of control by systems of cropping or farm practice based on more accurate knowledge of life history, habits and ecological relation of crops and pests, and to the possible prevention of insect ravages by early scouting or local surveys and to the exclusion of menacing foreign species by a study of their means of dispersal and the application of effective quarantine measures.

THE TRAINED WORKER.

It seems very clear then that the outlook so far as urgent problems and opportunities are concerned is sufficiently alluring in all lines of Agricultural Science. What can we as say to the attraction for the scientific worker? In the lines in which I am best acquainted, and I do not doubt in all phases of agricultural science, the outlook for capable trained men has been greatly affected by the call to service for national defense so that with greater appreciation and demand we are actually facing a serious shortage of competent workers. This must be accepted as a call not only to the training of promising recruits who may be attracted to such work but as a call to greater effort on the part of all of us who by reason of age or other circumstances are prevented from entering the most active lines of service. We may very well bestir ourselves for further effort and if perchance we have been looking forward to the day when the heavier burdens of our calling might be shifted to younger shoulders we may forego all such anticipation and in the words of ancient literature, "gird up our loins" anew for the duties of life. And, really, what more enjoyable or inspiring prospect can we have than active service in a work which is so full of opportunities for new achievement, so rich in posibilities for human advancement.

OUTLOOK FOR SUPPORT

The outlook from the standpoint of material support has never been so favorable, that is, measured by the funds devoted to research in agricultural science. To the individual investigator, however, there often comes a most discouraging handicap in the restrictions surrounding the use of grants for research purposes.

Dr. Eugene Davenport has very ably presented a protest against the increasing difficulties of meeting administrative regulations, devised and no doubt sincerely intended as safeguards against mismanagement and extravagance, but often involving vexatious delays and interference which may result in defeating the real purpose of the original grant.

Surely with the application of scientific methods we should be able to simplify and accelerate the processes of necessary expenditure so as to secure the greatest efficiency along with the best

spirit and most enthusiastic effort of the men who are anxious to devote their time and talent most effectively to the advancement of science.

I once had the opportunity to tell the responsible head of a scientific staff that in the prosecution of a certain study I had not been aware of the loss of a single hour of time for lack of the needed facilities in my work. I felt that he deserved a compliment for such organization and he replied (what would seem might be obvious to any man in his position) that he realized that the greatest expenditure for his staff was in salary for the personnel and that it would be most wasteful economy to permit their work to be delayed for lack of facilities. He argued that he might far better lose a small margin on unused apparatus than waste the time of high salaried experts on account of lack of apparatus when needed. Is not this principle well worth application in many phases of scientific work and is not the trained worker the best judge as to the needed equipment for his work.

I could cite instances where funds intended for certain work are so tied up that it may require weeks of time and the official sanction of five or six different offices before work can actually begin. Evidently the opportunity for the proper doing of the work may have entirely passed before a start can be made. "Time and tide wait for no man." The same is quite as true as to appearance of insect pests, plant diseases, the growing season of crops and the combination of conditions that may make possible the successful conduct of an investigation.

In every field of endeavor we can see the value of an *esprit de corps* that combines all effort in the accomplishment of the main purpose and while scientific workers have, no doubt, a full realization of the difficulties in the way of absolute freedom of action and relief from annoying obstacles, they yet are human and will respond as other bodies of human beings to the stimulus of encouraging conditions for the performance of their allotted tasks. Here lies one of the great opportunities of administrative officers, an opportunity I believe fully realized by many, improved by some and worthy of greater study by many more. I am not oblivious to the difficulty of discriminating between the conscientious and competent worker and the pretender in science as in other fields. This difficulty is all the more accentuated from the fact that the

product is so largely a matter of uncertainty. But the discriminating officer will learn to measure promise and performance here as elsewhere, while the recognition of work by scientific colleagues and comrades will aid his judgment as it serves in large degree as the compensation of the worker.

OUR ATTITUDE IN WORLD AFFAIRS

If we attempt a broad survey of scientific work and workers even in such a restricted field as that pertaining to Agriculture we are impressed with its universal and cosmopolitan character. The contribution of the single worker or the distinct branch becomes the property of the world of science which knows no boundaries, political or geographic, and while the results of research may be applied to ends both evil or good, the ultimate goal should never be in doubt.

While then, we assert with assurance that the agricultural science of today is contributing in large measure to the efforts of our country and our allies in this terrific struggle, may we not in an honest, optimistic forecast of future growth hope and expect that it will be recognized in the confidence and support of future generations whose needs it may serve.

For the immediate future all effort must be devoted to a settlement of the present war on terms of safety for the world. Then we may discuss whether science forthwith is to be degraded to diabolical deeds of destruction or consecrated to the constructive upbuilding of a civilization that means the welfare of all mankind.

With this issue determined I fully expect a great and glorious development of the science which commands our devotion and promises so much for the future of humanity.

It may seem superfluous on such an occasion as this to refer to our attitude toward the world's war. But at a time when all our boasted civilization seems hanging in the balance, when all the possibilities of progressive science are at stake, one may be pardoned for adverting to the topic which is uppermost in all our minds. And to me it seems that there can be but one answer as to our attitude in such a crisis. .

At a time when the rights of all mankind, all peoples and nations are challenged there is little use in splitting hairs about

our "constitutional rights" these are only tattered "scraps of paper" unless backed by the will of a united and powerful people.

In the presence of a great conflagration the "innocent spectator" who persists in getting in the way of the firemen is likely to get rough treatment, the plunderer who takes advantage of the situation to loot unprotected property is liable to be shot on the spot, while on the other hand the citizen who lends willing and effective aid will not be criticized if he come without a collar or has his coat on wrong side out.

Our workers in agricultural science are, I believe, true to the highest impulses of loyalty. They need no defense but is it not appropriate that we put on record our positive stand for American principles and world-wide liberty with a pledge of confidence and support for our government? A resolution of such character would, I believe, be fitting for this occasion and I will be pleased to entertain a motion for such a resolution at the proper time.

I would also suggest that our treasurer be authorized to invest any surplus funds in the society treasury in liberty bonds.

PERMANENT AGRICULTURE AND DEMOCRACY

(As suggested by the situation in China)

(ABSTRACT)

L. H. BAILEY, Ithaca, N. Y.

At the outset the speaker explained what is meant by the phrase "permanent agriculture." This expression is a real contribution to the discussion of rural affairs in recent time, expressing the idea that we must be able to maintain ourselves on the planet at the same time that the earth retains its producing power for all coming generations. It is important both because it demands the facts and also because it sets ideals for the future. It is the highest expression of being our brother's keeper—the brother who is yet to come. It suggests the most perfect altruism, and the truest socialism. Sometime this altruism will be the greatest concern of government—in the time when the concern of government coincides with the primary concern of mankind.

It has been said that permanent agriculture has been developed in the Far East. With King's sympathetic book, "Farmers of Forty Centuries," in his mind, and with opportunities to learn something of the rural situation in a few parts of the Republic of China, the speaker received certain impressions, and the reflections therefrom were the subjects of the address.

China is a people still in its agricultural phase, in which 85 per cent of the population is said to be engaged in farming, in which the public polity must be mostly a reflection of the rural situation.

At the same time, China is a land in which people in vast numbers live constantly on the verge between sustenance and want, in which the scale of living is reduced to the lowest terms for the mass of the people, in parts of which the labor of human beings may be worth less economically than of beasts of burden, and in which the people on the land are uneducated and the ideals undeveloped. The mere statement of the situation is a challenge of the agricultural status of the country, in the twentieth century, when expressed in terms of human beings. It is a challenge of most agriculture in the World.

China is a land of unnumbered people, of vast resources, stimulating history, stagnant in the occidental commercial sense, still under its own sovereignty, trying to adapt itself to the current ways of the world, a racial complex of marvelous vitality and endurance, constituting probably the greatest human problem on the planet. Its agricultural or rural status is the fundamental fact in this problem.

The speaker said that he went to China to find at last an exhibition of permanent agriculture. Here is solved the problem, apparently, of maintaining the fertility of the earth. Here also is said to have been solved the problem of the greatest possible yields, of the best disposition of human wastes, of the closest utilization of the land, the best conservation in the world, the elimination of the unnecessary accessories of life, and something like final rural individualism.

It is difficult for an occidental to judge any situation in the Orient. He must approach the subject largely from the objective point of view, yet remembering that the oriental may live largely in a subjective civilization.

The speaker said that his first impression was of waste land, and this impression grew on him. The smaller the divisions of land, the greater is the wastage of the partitions. In the best-tilled parts of the coastal plain, several per cent of the land is wasted by mere embankments and division lines. Much of the land is also taken by the grave mounds, and the unoccupied land near them is often left in such small and irregular areas as to be utilized with difficulty. In the interior, he was impressed with the vast shaven hills and mountains, the swamps and flats due to uncontrolled streams and lakes, the semi-deserts under no kind of effective control. One is everywhere impressed with the merciless skinning of the land, to get every last fragment of fiber and root for fuel.

Much has been said about the use and conservation of resources in China, whereby the last fragment is saved; but this is in the nature of private scavengering and is not public conservation of natural resources. In fact, it is quite the opposite, for it looks only to the present need and does not consider the future. It is more likely to be a vast practice of waste, looked at in the national and social sense, however well it may meet the needs of the present. It has no large result in it, no state policy, no bountiful

provision for the future. It is true that definite public plans of conservation are now under way, as in forestry, and in some places they are beginning to work out excellent results; but these are modern and recent adaptations or movements and not the result of the historical experience of China.

The first duty of agriculture is to produce supplies, and to maintain the fertility of the earth while producing them; and yet the measure of agriculture is not the yield, nor is it the maintenance of the greatest number of people on a given area of the earth's surface. Yet it is just this assumption on the part of both agricultural publicists and economists—that the test of agricultural excellence is that it sustain the greatest possible number of people—which is an underlying fallacy in present discussions. The greatest yield of agriculture is the human result, not the maintenance of given numbers.

King writes that he was "amazed at the amount of efficient human labor cheerfully given for a daily wage of five cents and their food, of fifteen cents United States currency, without food." You well know the slaving labor that is required, the long hours of mere grinding physical toil, the slender margin of profit, the skin-and-bone existence for the mass of the folk on the land, when people by millions give themselves for anything like five cents a day and their food. It does not matter what may have been the classification of the ranks of society by Confucius, placing the farmer only second in the scale of four, unless such classification works itself out in practice with those who actually handle the land.

Of course we are not to overlook or to deny the many highly developed manual agricultural practices of the Chinese and their neighbors. The Occident undoubtedly has much to learn from these patient toilers who for tens of centuries have produced supplies for such crowding millions and have still maintained the producing power of the earth. Their patience, persistence and elimination of all frills and unessentials, the heavy yields they secure in so many places, the painstaking care to the smallest detail, all inspire one's admiration; it is time that these people receive larger recognition before society; yet we are now projecting the broader results in human progress. Perhaps their painstaking is most apparent in the saving of human wastes and the application of it to the land; but one cannot think that this

method will be the final practice in society. We are not to solve the excrement problem on the scavenger basis, applying the raw material to the land, particularly now that we know its relation to carriers of disease. Such practice will never appeal to western peoples. If such waste is to be used for the land, it will be on the principle employed in the manufacture of commercial fertilizers or other treated and modified products, and not on the principle of the stable. Probably nowhere has the problem of the disposition of human waste been settled. Our present sewage systems are probably only temporary or transitory, when considered against the progress of civilization. Yet, the speaker said, he could not accept the oriental method as even an approximate solution of the problem. Nor is it yet evident that mere human waste is capable of producing the best yield indefinitely.

For the most part, the areas under cultivation in China are too small to allow a man to express himself on them. They make him to be a slave to mere hand labor, and doom him to a condition that has in it little hope of personal advancement. The problem before China in this respect, as before many other countries, is to produce the same or at least sufficient supplies with fewer men, with men of more power, more capital and turn-over in the business, more science and invention at their command, more mastery of the business, more economic and social freedom.

What is the acreage to the person in China is incapable yet of exact statement. King says, in the second edition, that there are "scarcely more than two acres per capita, more than one-half of which is uncultivable mountain land." Yet one is impressed in vast parts of the interior with the land awaiting reclamation or at least better utilization, with the bare hills, and also with what seem to be inadequate yields. Famine is an expectation in some of the agricultural regions. For every famine in any country, indictment should be brought against government.

A good part of the population in such countries as China will eventually be utilized in the industries: the countries will pass out of their rural phase. Whether the remaining rural population can secure sufficient additional production to the person, by means of machinery and more masterful handling of resources, to sustain the entire population can be little more than speculation at this epoch. It is probable that great fertile areas of the earth will

remain relatively sparsely settled and will supply the congested parts. One day we shall farm the seas. Perhaps synthetic chemistry will contribute something to the solution of the problem. Yet whatever the final solution, we must assume that the surface of the earth and its yields must always have significance, and that a certain large part of the race must exercise the arts of keepership.

Probably we make a mistake when we assume that the present rate of increase in population is to continue on the earth. But if the population is to increase to such an extent that all the people are to be reduced to existence-rations, all one can say is that the farmer should not be so reduced sooner than others. Certainly the man on whom the maintenance of the race depends should not also bear the burdens and the penalties of the race.

How to secure to the farmer in China or elsewhere the proper acreage so that he can afford to educate himself for his business is a very complex problem. It cannot be accomplished in a country like China without pulling up the very roots of society and civic order. It must be a process of adjustment and growth that works itself out very slowly. Whenever you touch agriculture, you touch the foundations of society.

Education in agriculture means larger and better holdings. There are persons enough who would vote public funds for the farmer if only he is to be kept in his proper sphere and not disturb the established order of things; yet the introduction of even practical agriculture into the schools means that the farmer is not to remain where he is, and that the present subdivisions of the earth are not likely to be adequate to men with more vision and more personal power.

It was not the speaker's object to suggest the ways of bringing about changes or what occidentals might call progress in the agriculture of China: that would be presumption: he approached the subject with no desire to criticize the Chinese or to offer them remedies or panaceas, but rather to evaluate the situation in terms of the Occident. With the Chinese themselves he is in greatest sympathy and his attitude is to learn what their situation, as a great school of experience, suggests for us. He has faith in the future of China, if it is left to the Chinese themselves.

We come now to see that the agriculture of China has direct relation to the constitution of the civic order in that country.

Agriculture has such relation in any country, but the relationship is particularly marked in China, in which the constitution of the body politic is yet evidently rural, or at least not industrial, and in which, also, the element of time has worked out certain results.

At this point the speaker took up a discussion of democracy, defining it and explaining some of its manifestations, suggested in large part by his travels and by observations of rural conditions. This discussion is omitted here, only the distinctively agricultural relations being printed in this place. In evaluating the farmer's place in society, he laid down the following formula, as expressing a fundamental relationship that must be grasped before we can deal effectively with the great rural problems in their human aspects:

The farmer is part of his environment, matching himself into his background, perhaps unconsciously, much as a bird is matched, or a tree, or a quadruped. His plan of operation, his farm-management, is an expression of his situation in nature: he has worked it out because it fits. He cannot shift it radically to meet the advice of any other person. As he himself develops in ability, he will modify his plan of operation so far as he can, but the plan must always fit his place in the environment; no great change is possible unless his natural conditions change: he does not make his conditions. The farmer exemplifies, in the human range, what the naturalist knows as "adaptation." His situation does not admit of compromise, perhaps not even of arrangement, and therefore it may not be understood by publicists, teachers, officials, and others.

The consequences of this formula, if it is true, are tremendous. All the advice given the farmer that does not recognize his necessary adaptation to his environment is useless; and useless advice is harmful. It is of no advantage to rail against the farmer any more than against the wind or the rain. It is idle to try to apply to him the pressures that are exerted on corporate business. It is of small consequence either to praise him or to condemn, to take sides for him or against him, except so far as it may affect his spirit as a man. When, under pressure of great crises, we radically change the conditions under which the farmer works, we must allow him time to readjust himself: he must take account of the latitude that he may reasonably expect in weather and soil and human forces. He needs not favors, but conditions that will allow him

to operate. The natural conditions within which he works cannot be changed, but they can be modified in some ways and he can make new adjustments within certain limits: these possibilities he begins to understand, and they are parts of his problem as a farmer; when the economic or outside conditions are changed, the modifications must be such as will match the natural limitations, if he is expected to adopt them.

The measure of your agriculture anywhere is the sufficiency of it as a source of supplies, together with the satisfactions and opportunities for comfortable living and advancement that it offers those who engage in it. Considered from this angle, the agriculture of China is not satisfactory and therefore is not successful: most agriculture, considering the world as a whole, is neither satisfactory nor successful.

This brings us to a statement of the two theories, or at least the two practices, as to the place of agriculture in society. On the one basis, the farmer comprises a substratum of human beings whose necessity it is to provide subsistence for higher strata from which are to come the leaders, thinkers, artists, rulers. On the other basis, the farm class itself is a lateral and co-operating factor in affairs, capable of producing leaders, thinkers, artists, rulers, a class co-ordinate rather than subordinate, directly related to civic needs: it is a class of this kind that I have always had in mind in my writings. I do not know how extensively this idea prevails, or is practiced, in other parts of the world.

You will agree that we cannot have a democracy on the former basis, which is the theory of the subordinate or peasant class. You will now better understand my earlier statement that the farmer is a fundamental fact in a democracy. In a book I once said that if agriculture cannot be democratic, then there is no democracy.

On the one basis rests autocracy, aristocracy, oligarchy, arrogancy, tyranny, stratified social systems, whatever the name of the government. On the other basis rests the possibility of free institutions.

The farmer should have equal privileges with any other man to develop himself and to partake in all affairs, not to be merely a mudsill on which a superstructure may rest.

Democracy rests on the land, on such a division of it and such an ease of acquiring it and such freedom of establishing new

ownerships and combinations, as will allow the farmer to buy and to sell it in his own name, and assure him the economic and civic freedom to make the most of himself as a man.

By this I do not mean that every person shall be a farmer, or that in the future state of society every man shall raise his own sustenance. This socialistic notion belongs to the idylls of poetry. But a man shall not be bound and chained to an hereditary piece of land.

These many statements (not all of which are reprinted here) have come out of a reflection on the situation in China. We are told that China has a permanent agriculture: I think this is the most serious difficulty with China.

We must distinguish sharply between permanent agriculture and stationary agriculture.

THE FUNCTION OF ORGANIC MATTER IN THE MAINTENANCE OF SOIL FERTILITY

By Charles E. Thorne and John W. Ames,
Ohio Experiment Station

It is very generally assumed that organic matter possesses a value for soil improvement additional to that of the nitrogen and mineral elements that it may contain. The object of this paper is to raise an interrogation point against that assumption.

At the outset let us be understood as not doubting that the elements of fertility which have been incorporated in living tissues are thereafter more available to crops than are the crude minerals of the rocks, and that the accumulation of organic matter as a reservoir of these elements is an essential feature of economic husbandry. The point under discussion is whether such material possesses any plant nutrient value—chemical, physical or biological—beyond that of the nitrogen and mineral elements which it may contain.

With one exception, the greatest yield of wheat of which the world has any record is the yield of 35.2 bushels per acre produced on Plot 2 in Broadbalk Field for 61 years, the treatment being 14 long tons, equivalent to 15.68 short tons of farmyard manure annually. The exception is the yield of 36.6 bushels per acre produced on Plot 8 in the same field over the same period without the addition of any organic matter of any description.

It is estimated that the manure used in this test has carried annually per acre 200 pounds of nitrogen, 34 pounds of phosphorus and 195 pounds of potassium, while the average increase over the unfertilized yield has removed only about 34 pounds of nitrogen, 7.5 pounds of phosphorus and 27 pounds of potassium, or 17 per cent of the nitrogen given in the manure, 22 per cent of the phosphorus and 13 per cent of the potassium.

The chemical fertilizers used on Plot 8 have carried annually 129 pounds of nitrogen, 29 pounds of phosphorus in available form and 83 pounds of potassium, and the increase has removed about 36 pounds of nitrogen, 7.9 pounds of phosphorus and 29 pounds of potassium, or 28 per cent, 24 per cent and 35 per cent

respectively of the amounts given in the fertilizers. Apparently, therefore, the plant nutrient elements of the manure have been less effective, pound for pound, than those of the chemicals.

Both the manure and the chemicals, however, may have been used in excessive quantities in this test. At the Ohio Experiment Station wheat has been grown continuously on the same land for 24 years with no other treatment than an annual dressing of 2½ tons, or 5,000 pounds, per acre of open-yard manure, which is estimated to have carried about 22 pounds of nitrogen, 5 pounds of phosphorus and 15 pounds of potassium. There has been an average increase for this treatment of a little under 6 bushels of wheat with 600 pounds of straw, estimated to have contained 11 pounds of nitrogen, 2 pounds of phosphorus and 8 pounds of potassium, or 50 per cent, 40 per cent and 53 per cent, respectively, of the quantities contained in the manure.

When the dressing of manure has been doubled the increase has been 10.3 bushels of wheat with 1,363 pounds of straw, carrying 19 pounds of nitrogen, 3.4 pounds of phosphorus and 13.5 pounds of potassium, or 43 per cent, 34 per cent and 45 per cent, respectively, of the quantities given in the manure.

Alongside of these manured plots two plots have received chemical fertilizers, made up of nitrate of soda, acid phosphate and muriate of potash, and carrying 25 pounds of nitrogen, 2.8 pounds of phosphorus and 12.4 pounds of potassium in the smaller dressing, and double these quantities in the larger one. The outcome has been a recovery of 56 percent of the nitrogen, 90 per cent of the phosphorus and 70 per cent of the potassium from the smaller dressing, and 49 per cent, 79 per cent and 68 per cent, respectively, from the larger one.

In both comparisons the percentage recovery has been greater from the chemicals. Averaging the two plots under each treatment we have a recovery of 46 per cent, 37 per cent and 49 per cent for the three elements in the manure, and 52 per cent, 84 per cent and 69 per cent for the same elements in the chemicals.

This comparison has been duplicated over the same period with corn and oats, with the outcome that in the corn 75 per cent, 44 per cent and 48 per cent of the three elements have been recovered from the manure, and 83 per cent, 69 per cent and 74 per cent from the chemicals, while the oats crop has returned

35 per cent, 28 per cent and 39 per cent from the manure and 52 per cent, 71 per cent and 51 per cent from the chemicals, the corn showing a relatively higher rate of nitrogen recovery than either of the small grains.

These experiments have been conducted on a soil depleted of its organic matter by a long period of tenant husbandry before the test began, and the average yields of the untreated land during the period of the test have been only 7.85 bushels per acre of wheat, 14.70 bushels of corn and 21.76 bushels of oats, so that there has been no reserve store of such matter.

The manure used in these experiments has been the ordinary manure of the open barnyard. No direct analysis of this manure has been made, but the composition assumed is based upon a large number of analyses of both fresh and exposed manures which have been made during the period included in this test, which have indicated an average composition for manure exposed for 3 months to the weather of 9 pounds of nitrogen, 1.94 pounds of phosphorus and 6 pounds of potassium per ton of manure.

Taking the average of all the crops and of the two rates of application the average recovery of the 3 fertilizing elements has been 68 per cent from the chemical fertilizers and 43 per cent from the manure.

During the same period of 24 years through which this experiment has been carried, corn, oats and wheat have been grown in succession followed by clover and timothy in a 5-year rotation, each crop being grown every year.

In this test the three elements have been applied separately, in pairs, and all three together, with the outcome that when phosphorus has been used alone at the rate of 20 pounds per acre for each 5-year period, there has been an increase of crop containing 30 per cent of the phosphorus given in the fertilizers, together with 44 pounds of nitrogen and 28 pounds of potassium.

When 76 pounds of nitrogen and 108 pounds of potassium have been given without any phosphorus the recovery has been only three-fourths as great as when phosphorus was given alone, but when 20 pounds of phosphorus was added to this dressing of nitrogen and potassium the recovery has been 110 pounds of nitrogen, 15 pounds of phosphorus and 73 pounds of potassium, or 184 per cent, 75 per cent and 70 per cent of the quantities given

in the fertilizer, thus showing the fundamental importance of phosphorus on this soil.

When 8 tons of manure has been given, carrying 72 pounds of nitrogen, 15.5 pounds of phosphorus and 48 pounds of potassium, there has been a recovery of 73 pounds of nitrogen, 9.4 pounds of phosphorus and 49.5 pounds of potassium, or 100 per cent, 60 per cent and 103 per cent of the quantities carried in the manure. In the average of the three elements, there has been a recovery of 100 per cent from the chemicals and 97 per cent from the manure.

At the ante-war prices of 20 cents a pound for nitrogen, 12 cents for phosphorus and 6 cents for potassium, and of half a dollar a bushel for corn, 40 cents for oats, one dollar for wheat and 10 dollars a ton for hay, the increase produced by the chemical fertilizers used in this test has been worth $2.03 for every dollar invested, and that from the manure, $1.84.

The conditions of this last comparison have been in favor of the manure, for all this work has shown that when either chemicals or manure has been used in small quantity the percentage gain has been greater than when the quantity has been increased.

In these experiments the chemicals employed have been nitrate of soda, acid phosphate and muriate of potash, except that about one-fourth of the nitrogen given to wheat has been carried in dried blood.

These results appear to me fully to justify the following conclusions:

1. That the value of manure or other organic matter in the maintenance of soil fertility is limited by the nitrogen and mineral elements contained.

2. That the physical improvement of the soil following the use of manure is due, not to the carbonaceous matter of the manure, but to the superior growth of plant roots induced by the nitrogen and mineral elements carried by the manure.

3. That this superior growth may be as readily and effectively obtained by the use of suitable nitrogenous and mineral salts as by manure.

4. That any favorable biological action following the use of manure will also follow that of chemical fertilizers, under ordinary farm conditions.

Let not these conclusions be understood as belittling the value of manure. If these conclusions are correct a ton of fresh stable manure, such as was used in these experiments, would be worth approximately $3.50, provided it was properly proportioned by the use of reinforcing materials to the needs of the soil and system of cropping, using ante-war valuations for chemical fertilizing materials, and this is a greater value than the ordinary farmer places upon it.

The farmer who learns to measure the value of his manure production by the pounds of nitrogen, phosphorus and potassium contained will handle it with greater care than does he who measures it only by the number of tons produced.

A REVOLUTION IN THE THEORIES AND METHODS OF SOIL CHEMISTRY

By Chas. B. Lipman
California Experiment Station

I have always regarded it as an unusually fortunate circumstance that there exists in agricultural circles a society such as this, whose chief aim, in my interpretation, is the furtherance and study of things affecting agricultural science in the large, and not so much that of the discussion of details in any branch of agricultural study. Constituting as it does, therefore, a sort of open forum for agricultural scientists, I believe the Society should be the place in which we may produce for general examination the status of our knowledge in any branch of our work. It gives us an opportunity to scrutinize critically, and yet broadly and judicially, some of our cherished opinions and experimental data. It makes possible such a scrutiny in a detached manner, so to speak, and gives us an opportunity to halt, for a brief spell, in the march of our progress, and in a more or less secluded spot by the roadside to ponder, undisturbed, on the *raison detre* of our theories and our methods.

I have thus spoken at some length in introducing the discussion which follows for the reason that I believe such introductory remarks important to a proper consideration of the main topic at issue, and for the purpose of explaining why I have chosen to bring such a subject before you.

It can probably be asserted with entire adherence to truth that no branch of agricultural science has been the subject of more intense study for so long a period as that of soil chemistry in its relations with soil fertility, and yet the subject in its more or less modern aspects has a history only of about three quarters of a century. Difficult as it was for de Saussure to bring home to his ultra conservative and incredulous contemporaries in the first decade of the last century the truth and pre-eminent significance of his hardly won and epoch making discoveries, it required but a relatively short time with the added powerful impetus of Liebig's logical and sarcastic report to the British Association in 1840 to obtain general acceptation for such discoveries anent the requirements for plant growth.

For about one century from the time of the appearance of de Saussure's masterly work and for considerably more than a half century after Liebig hurled his effective literary missile into the world of chemistry and physiology, little was written or done, however, to alter, in their essentials, the theories and methods of those distinguished investigators and their school. To be sure, much was being done during that time to contribute to a more detailed understanding of plants and soils. Indeed, none of us could justifiably underestimate the value to soils science of the investigations of Lawes and Gilbert and their associates and successors, of King, of Hilgard, and of many another bright star in the firmament of our science. Nevertheless, the work of all of these distinguished men contributed little, if anything, to a fundamental change in theories and hence in our methods of soil chemistry as applied to soil fertility. The later eighties, and the early nineties of the last century, saw the advent of a wholly novel and strikingly significant consideration into soil studies—that of soil bacteriology—which is, of course, indissolubly linked with soil chemistry. Deeply significant as it is and has been, however, soil bacteriology has not fundamentally changed our conceptions of how plants, in general, feed. Nor has it demonstrated, while showing how certain plant food elements are rendered water soluble from an insoluble state, the factors which markedly affect the nutrition of plants in media containing sufficient quantities of plant food elements in solution.

Contemporaneously with the advent of soil bacteriology and its contribution to soil science came a new theory. This, while not really a new theory, was responsible directly or indirectly for the development of a wholly new conception in soil theory which, with its development in the last decade, constitutes the revolution in soil chemistry to which the title of this paper refers. The revivified old theory to which I refer is the organic root toxin theory of de Candolle as presented by Mr. Milton Whitney and his associates of the Bureau of Soils. The really new conception and theory which sprang therefrom is the one which regards the soil and its solution as a physical-chemical system subject to the influences regulating such systems and profoundly influencing the plant which employs the soil solution as a medium of growth. For this conception, we are chiefly indebted in this

country to Mr. F. K. Cameron, and in Europe, to a considerable degree, to van Bemmelen for his celebrated studies on soil colloids and their properties.

The striking fact should be noted again that, with very slight modification the de Saussure conception of the soil as a nutrient medium held unobstructed sway until the appearance of Cameron's first publications on the soil solution. It regarded the soil as a reservoir for moisture which carried in solution certain components of the mineral constituents of the soil particles in such quantities as they were soluble in water and the weak acids added thereto as carbon dioxide and the other acids either secreted by the roots of plants or formed in the decomposition of organic matter. In this conception, there seemed never to have been considered or understood the possibility that certain laws regulate the solution of mineral soil constituents, that salts were as vital a factor as acids in solubility reactions, that ionization phenomena, the laws of chemical equilibrium and mass action, and the concentration and balance of the nutrient solution are vital factors to an approximation of a knowledge of the proper functions of the soil as a medium for plant growth.

But it required a generation for the scientific world of Europe to accept de Saussure's remarkable discoveries, and two generations more for the public at large, under the driving power of Liebig and his contemporaries and followers, to grasp their significance. It is, therefore, not surprising that the new conceptions for which, in my opinion, Cameron deserves most of the credit should not be immediately adopted. Due, however, to increased facilities for teaching and learning, the innate conservatism and orthodoxy of man in the case of the scientific world, was not so long in capitulating in this case. It required only about half a generation for soil scientists to become fully cognizant of the cogency and force of the general principles put forward by Cameron and his followers. Many soil chemists are even now groping for light amidst the old relics of a bygone generation of scientific thought, but it is probably safe to assert that the majority of our colleagues have seen the light and are fast approaching it, if they have not already attained thereto. The public, however, is still blissfully speaking of the soil theory of a bygone generation as new and wonderful and we shall probably have to

labor patiently for another generation to get the large part of the g. p. to see the validity of our present modern views and to accept them. It is hoped, in the interest of progress, that by that time we shall again be as far ahead of them as we are now, through the elucidation of the very difficult problems in plant nutrition which confront us at the present time.

You will naturally ask the question now, how does modern theory in soil chemistry differ from the old theory. Let us take a specific example to illustrate and emphasize the point. A decade ago, there were scarcely a handful of soil chemists who would have had the temerity to propose that we discontinue the use of the strong acid digestion method in soil analysis. The theory upon which that method was based was that it was equal to the task of indicating the portion of soil minerals which become available to crops in soils, with a fair degree of facility. This assumption was based on another assumption, to the effect that there exists in the soil, as we know them to exist in certain mineral deposits, compounds known as zeolites, which delivered up to solvents of no great power the bases held by them in considerable quantities. Moreover, the method of strong acid digestion of soil was based on an alleged correlation between the results of analyses made by it and the crops produced on the corresponding soils. We know now that the zeolitic theory and the alleged uniform correlations just mentioned are, to the scientific mind of today, wholly untenable. The facts and objections which are used in support of such assumptions and correlations may be explained very easily in other ways. Today, therefore, as contrasted with a decade ago, there are but few soil chemists who can see any value, practical or scientific, in the maintenance of a strong acid digestion method for soil analysis and as a means of indicating the crop producing power of soils.

In other words, the modern soil chemist can no longer see the cogency of methods which are wholly established on assumptions of questionable value. He cannot, in the light of modern chemistry, discern the utility, for none seems to him to exist, of the determination of a certain portion, arbitrarily delimited, of the total mineral constituents in soils. On the other hand, the methods of water extraction of soils, which a decade ago were considered by most soil chemists as wholly questionable in value

to soil chemistry and soil fertility studies, are now, in conjunction with the most modern studies on the soil solution, coming to assume a position of great importance in our work. Their use may be said to be very wide, if not general, and the laws of mass action and chemical equilibrium are always had in view when applications of these methods are made. Unfortunately, the soil solution is so complex a medium as to make impossible, as yet, any quantitative application of the laws just mentioned. Nevertheless, it does make possible the explanation of much that in recent years has seemed very mysterious, and, in a qualitative way, is casting much light upon hitherto very much vexed problems.

As another example of the striking metamorphosis through which soil chemistry has passed within the last few years, we may take the soil acidity question. Not more than five years ago, soil chemists almost without exception believed in one of two theories on the origin of acidity of soils. The first was the very old theory that acidity was produced through the formation in the soil of organic acids of a large variety by the decomposition of organic matter therein. The other theory, which was a relatively new one, consisted in the idea that soil acidity was produced by a lack of bases to satisfy so-called unsaturated silicates with the necessary base, or with the base necessary for full saturation, and hence blue litmus paper applied to soils containing such silicates must turn red without necessarily indicating the existence of free acidity. In the last five years, we have learned to consider both of these views and to evaluate them properly. We have now in hand indisputable evidence that soil acidity means nothing more nor less than an actual excess of hydrogen over hydroxylion. The distinction which even the most modern authors of textbooks on soils insist on drawing between positive and negative acidity seem to be both futile and sterile. Viewed either from the scientific or practical standpoint, soil acidity must be regarded as a condition produced by an excess of acid over base. Whether we have free acidity in the form of sulphuric acid, or oxalic acid, or carbonic acid, or some other free acid, or whether we have acid salts like the acid silicates, to which reference is made above, an excess of hydrogen ion exists in the soil solution and gives all the reactions in the laboratory and all the effects in the field which the reddening of blue litmus paper as a qualitative test indicates.

Moreover, the last three or four years have seen the adoption into soil chemistry laboratories of the method now in use for some time among physical chemists of the hydrogen electrode for the determination of the hydrogen ion concentration in soils. This gives an exact measurement of the hydrogen ion concentration in any soil and permits us to say for the first time with accuracy, just how acid or how alkaline a certain soil is.

In this manner, I might go on to recite before you instance after instance of the remarkable and speedy transformation through which the theories, and methods springing from them, in soil chemistry have passed within the last eight to ten years. Lack of time, however, will prevent my going into further detail, especially since I wish to consider briefly with you the general signification of all these changes. When summed up, the following points come clearly before us:

1. The total content of the soil in minerals containing the elements which are essential to plants gives little or no indication as to the value of a given soil for crop production.

2. We can no longer regard an element or compound as being available to plant roots merely because it is dissolved in the soil solution.

3. The reactions caused by salts in the soil solution are of equal moment with those which may be induced therein through the solvent powers of acids. Indeed, we recognize no fundamental difference between the two.

4. The available plant food elements in the soil solution must be measured by some method which accords more closely with the natural conditions under which plant food elements are rendered available in the soil solution than any method heretofore employed does.

5. Application of the laws of mass action and of chemical equilibrium in the soil solution makes it possible for us to conceive for the first time, with some measure of clearness, the laws regulating the solution of various phosphates in the soil, as well as of many other substances which are of vital importance to the plant.

6. The total concentration of the medium of growth, as has been recently demonstrated, is one of the important factors to consider in connection with the soil solution in our crop producing soils.

7. In addition, the proper balance between the nutrient elements, or between the salts in a medium in general, has been clearly demonstrated to be of the highest importance in a proper comprehension of the problem of the growth of plants in solution.

8. These conceptions make possible a much more rational approach to the study of the alkali problem in soils and clarify much in this problem which heretofore has been extremely puzzling.

9. Colloids of the soil as a factor in regulating the concentration of the soil solution, both by natural and artificial means, have come to be properly appreciated only within the last five or six years.

10. The nature of soil acidity and the methods for its determination, as above outlined, form a part of the new contributions of modern soil chemistry.

These considerations constitute some of the most important features, but only a few, which have contributed to the revolution in the theories and methods of soil chemistry within the past decade and they have rendered useless much of our highly prized and traditional methods. Thus the strong hydrochloric acid digestion method in soil analysis is about to go. The humus determination, it has been recently demonstrated, is fully as arbitrary and even less supported by correlations with crop conditions than the acid digestion method. The weak acid extraction methods are also waning in importance and all of these things have come to pass because there is a constant demand upon the part of the modern investigator in soil science for principles rather than facts, for a scientific rather than an empirical mode of procedure, and the insistent cry is being heard. Having tasted the nature of real science, we can no longer content ourselves with arbitrary assumptions and the unstable superstructure which has been erected on them.

Incidentally, the physical chemist who is thoroughly trained in that branch of science has not deigned to join our ranks as yet, but we need his help sorely. Even those who have imbibed enough of the principles of modern chemistry in our ranks to have fuller appreciation of the importance of more accurate and deeper thought in our problems are, practically in all instances, lacking in the necessary mathematical and physical training to attack

with the requisite power the extremely complex and abstruse problems which confront us and which for difficulty probably are equal to those of any other branch of science. It is probable that when the physical chemist does fully appreciate the beauty, as well as the complexity of our problems, he will be glad to avail himself of the opportunity to study them. Meanwhile, we are making progress, and, as indicated above, making it rapidly. Much still remains to be done, however, and we cannot have too much assistance, nor too much encouragement to speed the progress of the modern era, into which we have but just entered.

It must not be overlooked that in all of these matters, we owe a debt as partly acknowledged above, to those who, with the proper vision and the proper disregard for criticism, have long seen the coming of this new era, who have predicted it, and who have made material contributions to its start. To such men as Cameron, therefore, to van Bemmelen, to Wolfgang Ostwald and to Osterhout, among others, we owe a lasting debt of gratitude, which I, for one, am ready to acknowledge freely. In making this statement, I am not unaware of the numerous errors which the theoretical considerations of some or all of these gentlemen have introduced into the subject. I am fully cognizant of the numerous ways upon which we have improved upon certain theories and given certain explanations which have tended to clarify greatly our vision in these matters, but the responsibility for launching new ideas lies with those possessing the requisite degree of imagination, as well as technical training, to permit of the clear and concise formulation of their thoughts. In my opinion, therefore, soil chemistry has passed forever from the era of Liebig into a new era. It has completed the first five and certainly not more than the first ten years of this new era. May it continue in the future to make as rapid progress as it has in the past five years!

SHALL WE RECOMMEND THE USE OF MAGNESIAN LIMESTONE?*

A. G. McCall

It is not the purpose of this paper to attempt to answer this question, but to suggest the advisability of a more detailed study of the relative effectiveness of different limestones when applied to different soil types. In our experiment station literature we find frequent reference to the relative value of magnesian limestone as compared with the pure calcium limestone and many expressions of opinion, but practically no experimental evidence bearing upon the subject.

Observations of the farm practice with respect to liming in certain sections of Maryland has led the writer to the conclusion that an intelligent answer to this question requires a knowledge of the origin and character of the soil under consideration. In the vicinity of certain marble and limestone quarries in the State, the farmers send to other sections for their agricultural lime instead of utilizing the material close at hand, asserting that the local material is ineffective when applied to their soil. This same local material, however, is shipped to other localities where it appears to be very effective for agricultural purposes. These considerations have led the Soils Department of the Maryland Experiment Station to take up a study of the response of certain soil types to the applications of lime and limestone containing different proportions of calcium and magnesium. It is our plan to study the response of some of the more important soils, first in pot cultures in the greenhouse and later to carry the work into the field.

Although the work in the greenhouse has been completed for but a single soil type, the results are so significant as to warrant their presentation at this time.

Since it seemed reasonable to expect that the initial ratio of calcium to magnesium in the soil would have an important bearing upon the results, it was decided that a soil relatively high in magnesium should be selected for the first series of cultures. Accordingly a large sample of red soil (probably Penn Loam) was secured from Frederick County, Maryland. This sample was

*Contribution from Dept. of Soils, Maryland Experiment Station.

found to contain approximately twice as much magnesium as calcium, the analysis showing 1.15 percent. of magnesium and only 0.59 percent. of calcium. After drying and pulverizing the soil was divided into ten uniform lots, with each of which was incorporated the desired quantity of the different limes and limestones. Two paraffined clay pots were then filled from each lot, the pots being provided with Livingston auto-irrigators in order to insure a uniform supply of moisture. As soon as the soil had attained an optimum moisture content the pots were seeded to red clover and afterwards thinned to a uniform stand of six plants to each pot.

The treatments of the different pots of soil are shown in Table I.

TABLE I.

TREATMENT OF SOIL POTS.

Pot No.	Treatment	% Composition of Material		Yield of Clover
		Ca	Mg	Grms.
1 20	No treatment	0	0	1.072 1.137
2 19	2 T. Raw Limestone	49	5	2.150* 3.018
3 18	2 T. Raw Dolomitic Limestone	30	19	1.751 1.815
4 17	2 T. Raw Dolomitic Sand	30	20	1.428 1.679
5 16	1.5 T. Hydrated Oyster Shell	60	0.4	2.820 3.155
6 15	1.5 T. Hydrated Lime	70	2	3.865 3.518
7 14	1 T. Burned Lime	93	3	3.011 2.804
8 13	1 T. Burned Lime	86	4	3.636 4.221
9 12	1 T. Burned Lime	86	14	4.050 4.109
10 11	2 T. Raw Ground Oyster Shell	51	0	3.443 3.280

*Auto-irrigator broken. Results discarded.

From Table I it will be seen that composition of the material employed ranges from practically pure calcium carbonate as found in the oyster shell to the dolomitic stone in which the ratio of calcium magnesium is 3 : 2. In the last column of table I is given the dry weight of the clover for each duplicate pot at the close of growth of 114 days.

Table II gives the relative dry weights for each treatment as obtained by dividing the average weight of the duplicate pots by the average weight of the duplicate checks. The diagramatic part of the table gives a graphic representation of the relative increase of the growth rate of the clover for the different treatments and a comparison of the weight of these cultures with that of the checks receiving no treatment.

TABLE II.

REL. YIELDS		CA O	MG O
1.00	CK.	-	-
1.41	DOL SAND	30	20
1.61	DOL. STONE	30	19
2.63	B. STONE	93	3
2.71	HYD. LIME	60	0.4
2.73	R. STONE	49	5
3.04	R. SHELL	51	-
3.34	HYD. STONE	70	2
3.56	B. STONE	86	4
3.70	B. STONE	86	14

Table and diagram showing the relative yields of clover secured by the use of different materials. The first column gives the relative yields while the columns to the right give the ratio of lime to magnesia. The shaded portion of the diagram indicates the increase over the checks which received no lime.

From this table it will be seen that while both the dilomitic sand and the dolomitic stone gave substantial increases over the check cultures, their effectiveness is less than one-half in some cases and less than one-third in others, when compared with the oyster shell and limestones of low magnesium content. Attention is called to the fact that the burned stone containing 14% of magnesia gave slightly better results than the materials containing no magnesia or only small amounts. This would suggest that up to a certain maximum the presence of some magnesium in agricultural lime is beneficial and increases its effectiveness. This is in harmony with the opinions expressed by several experiment station writers. It remains to be determined, however, if these materials will show the same relative effectiveness when applied to a soil in which the natural calcium content is greatly in excess of the magnesium.

Further study of these data gave evidence of the fact that the fineness of the material is also an important factor in determining the relative effectiveness of the materials. Indeed it is quite probable that the increased effectiveness of the burned lime is closely associated with the fine state of division into which it passes when brought into contact with the soil.

THE INFLUENCE OF THE DEGREE OF FATNESS OF CATTLE UPON THEIR UTILIZATION OF FEED*

By Henry Prentiss Armsby, Director, and J. August Fries, Assistant Director, Institute of Animal Nutrition of The Pennsylvania State College.

In the fattening of cattle it is a common experience that the gain in live weight secured per unit of feed consumed diminishes as the fattening progresses. Little reflection is required to make it evident that this phenomenon may be the combined result of a variety of causes. A supposed lower utilization of feed by the fattened as compared with the thin animal has been regarded not uncommonly as one such cause. It has been supposed that with the progress of the fattening the body cells become less efficient in the manufacture of fat from other nutrients or that the cells of the adipose tissue, as they become loaded with fat, offer, as it were, an increasing resistance to the deposition of added fat, to overcome which requires an expenditure of energy. In either case a unit of a resorbed nutrient, such as dextrose for example, would yield less fat than in the thin animal while the heat production would be correspondingly increased and the net energy value of the feed reduced.

The investigation here reported was undertaken to test the relative importance of this as compared with other possible factors by means of a direct comparison of the utilization of feed energy by the same steer in ordinary condition and when well fattened. Although it includes only a single comparison on one animal the results appear of some interest in view of the paucity of experimental evidence on this point.

OUTLINE OF EXPERIMENT

The subject of the experiment was a pure-bred Shorthorn steer about two years and nine months old at the beginning of the experiment. He was a very quiet and docile animal. During the winter of 1912-13 he was the subject of a series of respiration calorimeter trials (unreported). During the following summer he

*Co-operative investigations between the Institute of Animal Nutrition of The Pennsylvania State College and the Bureau of Animal Industry of the United States Department of Agriculture.

was on pasture and gained some 240 pounds in weight. On October 21, 1913, he weighed 1141 pounds and was put on a preliminary ration of the same feed mixture used in the experiment proper, which began on November 2, 1913. At that time the animal was in good condition, but not fat. A standard feed, consisting of one part by weight (air dry) of alfalfa hay and two parts of a mixture of concentrates, was used throughout the experiment. The mixture of concentrates employed consisted of one part by weight (air dry) of cottonseed meal, two parts of wheat bran and six parts of maize meal. During Period I an approximate maintenance ration of this standard feed was given while during Period II this amount was increased to the maximum which the animal would consume. A comparison of these two periods in the same manner as in previous investigations served to show the utilization of the feed by the animal.

At the close of Period II, on December 22, the steer was placed in the hands of the Animal Husbandry Department of the College for fattening and was fed by them until March 14, 1914, during which time he gained about 300 pounds and was brought into prime condition.

In the second half of the experiment, beginning March 15, 1914, the comparison of Periods I and II was repeated in the reverse order. In Period III the animal was given as heavy a ration of the standard feed mixture as he would consume, a little being, in fact, left uneaten. This was followed by Period IV, in which an approximate maintenance ration was fed. A comparison of Periods III and IV served to show the utilization of feed energy by the fattened animal.

METABOLIZABLE ENERGY

The losses of energy in feces, urine and methane is each period were determined in the usual manner. The results afford data for computing for the total rations the percentage losses of energy in the several excreta and the percentage metabolizable. On the assumption that the corresponding values for the alfalfa hay were the same as those found for the same hay in the experiment upon the same animal during the previous year, the corresponding figures for the concentrate mixture may also be computed. The results are recorded in Table I.

TABLE I

PERCENTAGE DISTRIBUTION OF ENERGY

	Percentage Losses			Percentage Metabolizable
	In feces	In urine	In methane	
Total ration:				
Period I	24.44	5.16	9.15	61.25
Period II	26.61	4.55	6.72	62.12
Period III	25.88	4.91	6.48	62.73
Period IV	24.42	5.38	8.80	61.40
Assumed for hay	42.60	5.92	6.77	44.71
Computed for concentrates				
Period I	15.62	4.79	10.30	69.29
Period II	18.81	3.88	6.70	70.61
Period III	17.80	4.42	6.34	71.44
Period IV	15.64	5.11	9.78	69.47

As in earlier experiments, the heavier rations suffered relatively greater losses of energy in the feces but smaller ones in urine and methane, so that the percentage of the gross energy which was metabolizable was slightly greater on the heavier ration. It must be remembered also that the metabolizable energy as here computed includes that evolved as heat in the methane fermentation. Estimating this at 6.07 Cals. per gram of methane*, the proportion of the gross energy of the rations which was available to sustain the tissue metabolism averaged 57.24 per cent. for the lighter rations and 59.43 per cent. for the heavier. No distinct difference in this respect was manifest between the unfattened and fattened condition.

BODY INCREASE

From the income and outgo of nitrogen and carbon as determined with the respiration calorimeter the amounts of protein and fat stored in the body may be computed upon the usual assumption that the stock of carbohydrates in the body remained substantially unchanged. The average results for the four periods are contained in Table II.

* Jour. Agr. Research, 1915, v. 3, No. 6, p. 468.

TABLE II

DAILY GAINS OF PROTEIN AND FAT

	Protein	Fat	Total Organic Matter
	Grams	Grams	Grams
Period I	14.4	89.0	103.4
Period II	120.0	822.0	942.0
Period III	107.4	615.9	723.3
Period IV	-51.0	-28.3	-79.3

The foregoing figures may serve as the basis for some approximate comparisons. Assuming the percentage of organic matter in the total gain in live weight to have been the same as that observed by Lawes and Gilbert for fattening cattle, viz., 73.89, the gains of organic matter recorded in Table II, are equivalent to a gain in weight of 1.275 Kgs. (2.8 lbs.) per day in Period II and 0.979 Kgs. (2.2 lbs.) in Period III. The experimental periods were too short to permit very satisfactory conclusions to be drawn from the live weights of the animals but the rates of gain just computed appear to correspond fairly well with the observed weights.

A comparison of these estimated gains in weight with the feed consumption yields the results of Table III. Obviously, no great accuracy can be claimed for these computations, but nevertheless they show clearly a decreasing efficiency of the total feed.

TABLE III

FEED CONSUMED PER UNIT OF ESTIMATED GAIN IN WEIGHT

	Total Feed	Dry Matter	Digestible Organic Matter
Period II	8.2	7.2	5.2
Period III	11.6	10.1	9.6

ENERGY EXPENDITURE CONSEQUENT UPON FEED CONSUMPTION

The average daily heat production of the animal, corrected to a uniform period of 12 hours standing and 12 hours lying, as in our earlier experiments was:

Period I	10905 Cals.
Period II	16511 Cals.
Period III	19992 Cals.
Period IV	14095 Cals.

The foregoing results show the same marked increase in heat production which has been uniformly found to follow an increase in the ration. From a quantitative comparison of the corresponding periods, the energy expenditure per unit of total feed (hay and concentrates) consumed may be computed in the case of the unfattened and fattened animal, respectively. The results of this computation are contained in Table IV. For the reasons stated in a previous paper* no attempt has been made to correct these results for the differences in live weight.

TABLE IV

ENERGY EXPENDITURE PER KILOGRAM DRY MATTER OF TOTAL RATION

		Dry Matter Eaten	Heat Production
		Grams	Cals.
Unfattened	Period II	9146.3	16511
	Period I	4462.9	10905
	Difference	4683.4	5606
	Difference per kilogram dry matter	......	1197
Fattened	Period III	9911.6	19992
	Period IV	5215.6	14095
	Difference	4696.0	5897
	Difference per kilogram dry matter	......	1256

*Jour. Agr. Research, 1915, v. 3, No. 6, p. 471.

The results are of quite the same order of magnitude as those obtained in previous experiments on similar mixed rations of hay and grain. In the fattened animal there appears to have been an increase of about 5 per cent. in the energy expended in the various processes intermediate between the prehension of the feed and the storage of protein and fat in the tissues. To this extent the experiment sustains the view outlined in the introductory paragraphs. The difference, however, is small and it is perhaps questionable whether it exceeds the experimental error. At any rate, it is far from accounting for the very marked difference in the economic utilization of the feed which is indicated by the approximate calculation of Table III and is of little significance in comparison with another factor to be considered immediately.

THE MAINTENANCE REQUIREMENT

The comparisons of Table IV also afford data for computing the basal katabolism of the steer in the manner described in an earlier publication.*

Each kilogram of dry matter consumed increased the katabolism by 1197 Cals. in the unfattened and by 1256 Cals. in the fattened state. It may be computed, therefore, by how much the katabolism would have been reduced had the feed been entirely withdrawn, while subtracting this amount from the observed heat production will give the fasting katabolism. The calculations for Periods I and IV are:

Period I, unfattened, 10,905—(1197×4.4629) = 5563 Cals.
Period IV, fattened, 14,095—(1256×5.2156) = 7544 Cals.

Similar computations for Periods II and III would, of course, yield the same results.

The results per head and also those computed to a uniform live weight of 1000 pounds for the sake of comparison with other data are shown in Table V.

*U. S. Dept. Agr., Bur. Anim. Indus., Bul. 128, p. 53.

TABLE V

COMPUTED FASTING KATABOLISM PER DAY

	Per Head	Per 1000 Pounds Live Weight	
		In Proportion to Weight	In Proportion to Two-thirds power of Weight
	Cals.	Cals.	Cals.
Unfattened	5563	4919	5125
Fattened	7544	5275	5943

In the unfattened state the animal had a rather low basal katabolism, the average of 23 similar determinations by the writers being 5906 Cals. per 1000 pounds as compared with 5125 Cals. in this case.

It is evident that the major factor determining the lower economic efficiency in the fattened state was the very marked increase (36%) in the basal katabolism. Doubtless this increase was due in part to the greater body weight to be supported while standing but, as the table shows, it was greater than would be computed from the increased weight or the surface as estimated by the Meeh formula. Apparently the accumulation of fat tended in some way to stimulate the general metabolism. These results are quite in harmony with those obtained by Kellner and Köhler in experiments on the same subject. This greater maintenance requirement, together with the relatively somewhat smaller feed consumption, was chiefly responsible for the more expensive gains by the fattened animal.

Another factor acting in the same direction is the probable greater energy content of a unit of gain in live weight. From the estimated increase in live weight and the daily gain of energy shown in Table 7, it may be computed that the energy content of one kilogram gain in weight was approximately:

In Period II........................6.970 Therms
In Period III.......................8.042 Therms

In other words, the amount of either net or metabolizable energy in excess of maintenance required to produce a unit of gain in weight was greater with the fattened animal. This would be still more true if the maintenance were computed in proportion to weight or surface.

NET ENERGY VALUES

From the foregoing the net energy values of the rations may also be computed as shown in Table VI.

TABLE VI

NET ENERGY VALUES OF TOTAL RATIONS PER KILOGRAM DRY MATTER

	Gross energy	Losses in excreta	Heat increment	Net energy value
	Cals.	Cals.	Cals.	Cals.
Period I	4488	1739	1197	1552
Period II	4470	1693		1580
Period III	4481	1670	1256	1555
Period IV	4478	1728		1494
Average for light rations	4483	1733	1227	1523
Average for heavy rations	4476	1682	1227	1567
Average in unfattened condition	4479	1716	1197	1566
Average in fattened condition	4480	1699	1256	1525

The relations shown in Tables IV and VI may also be expressed in another way by comparing the percentages of the metabolizable energy which were recovered in the gain made in the unfattened and fattened states, respectively, as shown by the energy balances.

TABLE VII

PERCENTAGES OF METABOLIZABLE ENERGY RECOVERED IN GAIN

		Metabolizable Energy	Body Gain	Percentage Recovered
		Cals.	Cals.	Per Cent.
Unfattened	Period II	25398	8887	....
	Period I	12269	1364	....
		13129	7523	57.3
Fattened	Period III	27865	7873	....
	Period IV	14338	243	....
		13527	7630	56.4

SUMMARY

1. A steer in medium conditions received, in two successive periods, an approximate maintenance ration and a fattening ration of the same standard mixture of hay and concentrates. The animal was then fattened and the comparison of a maintenance ration and a fattening ration of the same standard feed mixture was repeated.

2. In consequence of the smaller losses in the urine and especially in the combustible gases the percentage of the gross energy of the feed which was metabolizable was greater on the heavier than on the lighter rations. No difference in this respect was observed between the fattened and the unfattened animal.

3. The heat increment resulting from the consumption of a unit of feed was but little greater in the fat than in the thin animal. Consequently the net energy values of the feed and the percentages of the metabolizable energy which were available for gain were but slightly less in the fattened than in the unfattened condition.

4. The maintenance requirement of the steer was increased 36 per cent. by a three-months fattening in which the live weight was increased by about 300 pounds. This increase was greater than corresponded to the increase in weight or in computed body surface.

5. The lower economic efficiency of the fattened animal in this experiment was due chiefly to his higher maintenance requirement and only to a small extent if at all to a difference in the utilization of the surplus of feed over the maintenance requirement.

THE MINERAL METABOLISM OF THE MILCH COW

By E. B. Forbes
Ohio Experiment Station

The cow is foster-mother of the human race. This relation, older than the art of writing, grows in prominence as a factor in nutrition with our advance in the science of living; and on both physiologic and economic grounds we anticipate continued increase in the contribution of the cow to the human diet.

These grounds, for this expectation, are, that the cow is by far the most economical producer of proteid nutriment; that among proteins in general those contained in milk possess a maximum nutritive value; that milk possesses other important growth-promoting principles the exact nature of which is as yet unknown; and that no other food carries such an abundance of mineral nutrients of desirable kinds and combinations. No other food has an equal value for the general purpose of health insurance.

Since milk is preeminently a proteid food it is natural that the proteid requirement of cows should have been worked out with great elaboration, and that successful milk production should depend on a practical recognition of the cow's imperative need for the proteid raw material which she is to transform.

The fact that the cow is also unparalleled as a producer of mineral nutriment, and that her mineral food requirements must be of a corresponding order, appears to have been overshadowed by the more prominent facts as to her nitrogen metabolism; and we have not been obliged to study the cow's mineral metabolism since in the provision of her more obvious requirements we have incidentally and unintentionally done fairly well in providing the necessary mineral substances. In this day of rigorous searching for the true inwardness of things, however, we should no longer delay a careful examination into the terms on which the cow conducts her extensive mineral exchange.

During the past three years the main line of work of the Department of Nutrition at the Ohio Agricultural Experiment Station has been an investigation of this subject. A year ago I pre-

sented to this society a progress report of this work. We now have additional evidence which clears up the field to such an extent as to warrant a further statement of the case.

This program of investigation consisted of three experiments, with six cows in each. There were three experimental periods in the first test, and two in each of the others. Our conclusions rest, therefore, on 42 individual studies. In each case we made complete mineral analyses of food, milk, urine and feces. These data make it possible for us to determine, in each case, whether the cow was gaining or losing in the amounts of the several mineral constituents of the body.

The cows were all unregistered Holsteins of essentially pure breeding. As an indication of their character as milk producers, the average daily yield of milk during the first test was 36 pounds, and during the second and third, about 47 pounds. They were good, common, profitable cows; better than the average, but of a quality readily attainable by selective breeding. The results, therefore, apply to practical milk production.

The rations were composed of normal foods in practical combinations. Sixteen such rations were studied. Corn was always used as the principal concentrate; with this we used commercial protein supplements such as wheat bran, cottonseed meal, linseed oilmeal, distiller's grains and gluten feed. Corn silage was fed in 11 of the 16 rations. The hay used was clover in 8 rations, alfalfa in 7 and timothy in one. To rations compounded from such feeds we added mineral supplements of the following kinds: common salt, steamed bone flour, precipitated bone flour, calcium carbonate, calcium lactate and calcium chloride.

As much food was given as would be cleaned up without waste. The amount of food was usually just about sufficient to maintain live-weight during the liberal milk production, but there were slight gains in weight with more than half of the cows. As a further indication of the plane of nutrition, there was protein storage in 29 out of the 42 balances, or 70 per cent. The cows therefore, were well nourished on the best of foods; the results are not in any case due to general underfeeding. The cows which gained in weight did not differ appreciably, in their mineral metabolism, from those which lost a little weight.

Now as to results—asking you to take for granted the voluminous statistical data of this study, and its extended scope, I shall call attention to only a few of the more obvious conclusions and to their practical significance.

Probably the most generally significant fact which has come out of this study is the demonstration that the status of the milch cow with reference to her mineral metabolism is distinctly different from her status as to protein and energy metabolism; that the selective improvement of the milch cow has proceeded unevenly, as to the several functions involved, the capacity to assimilate the organic nutrients required for milk production having outrun the capacity to assimilate the minerals; thus during ordinarily liberal milk production, without regard to the protein metabolism, and in spite of protein storage and gain in live-weight, cows commonly draw upon their bones for greater amounts of the constituent minerals than they are able to assimilate from the ration. We derive these conclusions from the balance data for calcium, magnesium and phosphorus.

In the first experiment, nitrogen was retained by every cow in all three periods. At the same time calcium and magnesium were lost in every case, and phosphorus was lost in 15 cases out of the 18. The greatest calcium loss occurred in Period I, during the feeding of a ration composed of timothy hay, corn, corn silage and cottonseed meal. In later periods, the calcium intake was increased from two to two-and-a-half times by the substitution of clover for timothy hay, but the calcium loss was reduced very little. These cows, in need of calcium, and supplied with an abundance (largely in clover hay), were unable to utilize it.

In the second experiment the basal rations, fed in Period I, were very rich in calcium; all contained either clover or alfalfa hay. The calcium, magnesium and phosphorus balances were all negative. In the second period the mineral intake was still further increased by the feeding of steamed bone flour or calcium carbonate. In this period phosphorus balances became positive, in response to the increased intake of this element; magnesium remained negative in five cases out of six, while the outgo of calcium, as usual, was in every case greater than the intake. This storage of phosphorus must have occurred in the soft parts, since the loss of calcium indicated a continued withdrawal of this element from the bones.

The third experiment was similar to the second; but the calcium content was increased in the basal ration by dropping out corn silage and using alfalfa as the only roughage. In the other rations the calcium content was still further increased, to about six times the quantity contained in the timothy hay ration of the first experiment, by the addition of calcium lactate, precipitated bone flour or calcium chloride. The unsupplemented rations caused invariable losses of calcium and phosphorus, and losses of magnesium in five cases out of six. The supplemented rations in which we fed large amounts of readily soluble calcium compounds did not cause improved retention of mineral substance. All balances of calcium, magnesium and phosphorus were negative.

In this series of three experiments we exercised our best ingenuity to compound rations containing maximum amounts of calcium, magnesium and phosphorus, and then increased the quantities present by the addition of large amounts of mineral salts; still phosphorus was lost in 79 per cent., magnesium in 95 per cent. and calcium in 100 per cent. of the balance periods.

We have investigated several possible causes of the limited capacity of cows to utilize these minerals. Thus our results show that it was not due to lack of proper proportion among the mineral nutrients of the rations; nor to deficiency of common salt from which is formed the hydrochloric acid of the gastric juice; nor to difficult solubility of the supplements used, since even the water-soluble calcium lactate and calcium chloride were poorly utilized. The limiting factor must reside in the process of assimilation of the mineral nutrients by the bones.

It is true that most of the losses of minerals which we have demonstrated were small, in comparison with the extent of the cow's mineral stores; and that these overdrafts would be repaid later in the period of lactation, when the milk flow, and therefore the draft upon the mineral reserves of the skeleton, would have become sufficiently reduced—provided the conditions of feeding were favorable. The practical bearings of this investigation consist of the application of the facts to the less favorable conditions which are often unavoidable in practice.

Another point made clear by our studies is the large measure of independence which exists in the metabolism of the several elements studied; thus calcium, magnesium and phosphorus, on

account of their occurrence together in such quantities in the skeleton, might be expected to manifest a close interrelationship in metabolism, but in this investigation we found calcium and magnesium to an appreciable extent independent of each other, while phosphorus, by virtue of the considerable quantities contained in the soft parts, was sometimes retained during periods in which both calcium and magnesium were lost.

Nitrogen and sulphur commonly appeared to follow the same laws, as would be expected on account of their association in the proteins; but this was not invariably so, since in 9 cases out of the 42 the signs of the balances differed; that is, one of this pair would be stored while the other was given off in amounts greater than the intake. These differences probably depend upon the considerable variation which exists in the relative amounts of nitrogen and sulphur in the nitrogenous structures of the body, having in mind especially hair and flesh.

The lack of a close relation between nitrogen and the minerals of the bones, in their metabolism, is conspicuous. Bone starvation may proceed for some time without seriously affecting the gross body metabolism; but as to the effects of negative balances of the mineral elements of the bones on the more specialized functions of the body, we have almost no direct and satisfactory evidence.

It thus appears that the qualitative character of metabolism is highly variable; the body does not gain and lose in each of its constituents at a definite proportional rate; but rather, it exhibits a surprising degree of purposive metabolic adaptability.

As confusing a situation as any developed by our inquiry is due to the obtaining of negative balances during periods of excessive intake; thus the elimination of a nutrient in amounts greater than the intake may signify either deficiency in the food, or the unloading of previously absorbed stores in the face of continued superabundant supplies. Our mere measurement of intake and outgo leaves us without a clue as to what these transfers signify in biochemical terms. It would appear that we have not appreciated the long-continued and extensive transfers of mineral nutriment which are set in motion by changes of rations.

I suspect that we shall not really solve the problems of this field until we have series of balance periods covering the whole of the life process of interest. Such a program, in the field of

mineral metabolism, would be very expensive, since complete ash analyses of all substances involved are required by the complicated interrelationships which exist between the mineral elements.

The most difficult part of such an investigation is the safe application of the results to practical affairs—difficult because the environment of the animal is composed of such a complication of influences that it is impossible to determine the proportionate contribution of each of them, especially of the obscure and intricate facts of mineral metabolism; and also because, on account of the supreme importance of mineral metabolism, the animal is so wonderfully protected by mineral reserves and other safety provisions that unfavorable effects of treatment are slow to appear and are difficult to demonstrate in a clear-cut manner.

We have determined that liberal milk production involves a certain degree of impoverishment of the skeleton in mineral substance. This is necessitated by the fact that the cow is unable to assimilate minerals as rapidly as she must liberate them. What should this fact mean to the practical man?

Now let us consider the conditions occurring in practice coincident with this loss of mineral substance. For the present we shall be obliged to use our unaided practical judgment as to the probability of essential connections between these practical conditions and the mineral losses, and the extent of the contribution of these mineral losses to the production of the unfavorable results. Our general ground for assuming that there is an essential relation between this loss of minerals and concurrent unfavorable states of nutrition is that this loss, be it great or small, subtracts just so much from the capability of the organism to meet further like demands. This disadvantage comes to have an added significance during periods of stress, when the slight loss observed under optimum conditions may become a large one, and when the effects of any loss may be magnified by the critical character of the animal's nutritional situation.

By systematic correspondence with professors of dairy husbandry and veterinary science and with state veterinarians, and by a study of the literature, I have obtained a fair idea of the intelligent opinion in this country on the practical aspects of this

subject. I would observe, however, that any such record of opinion is of greater value in raising questions than in settling them.

There is general agreement that sterility is common among milch cows, wherever large numbers of them are brought together in an intensive program of feeding, breeding and milk production, and that this failure to breed is becoming more prevalent. Much current opinion relates this situation to contagious abortion alone, but others, who would be considered as competent to judge of the facts, are positive that a large proportion of the cases must be due to the operation of some other important and unexplained factor. It is reported on the best of authority that occasionally whole herds will fail to breed, during a limited period, apparently because of their state of nutrition, there being no evidence of contagious abortion.

At the same time there is a belief, so prevalent that we may regard its truth as established, that failure to breed is decidedly common, though by no means invariable, after especially heavy and protracted milk production, which we have learned calls for overdrafts at the mineral bank. It is also the prevailing opinion that failure to breed is more prevalent among dairy than among beef cows, and that the higher the dairy development of the cow the more frequently will there be difficulty in getting her to conceive. It is the prevailing belief that this physiological disturbance is an effect of the combination of intensive milk production, heavy feeding and the restraints of an unnatural environment.

In the literature we find several references to the prevalence of malnutrition of the bones following seasons of excessive heat and drouth. This condition is related to the deficient mineral content of the forage, due to subnormal transpiration of mineral-bearing moisture from the soil. By laboratory studies I have found that there may be such an effect of limited water supply on the mineral content of plants, but I do not discover any general opinion that drouth leads to malnutrition of the bones. It is well known, however, that the partial starvation which is caused by seasons of drouth and food shortage is followed by increase of sterility and abortion. Any general injury of forage crops which results in loss of vitality in the cattle has like consequences.

It is also generally understood that gross overfeeding, overallowance of protein, or any marked lack of balance in the ration, due to excessive proportion of certain feeds, even though they possess great nutritive value, may cause sterility and abortion; thus cottonseed meal, peanuts and velvet beans, when used to excess, are believed to cause sterility and abortion; and even alfalfa, the very cream of forage plants, has been the cause of much complaint on the same score, when it is used to the practical exclusion of other feeds. The case against alfalfa has not been established, but many men whose interests are involved consider this a live problem. Of course this is quite without bearing on the normal use of alfalfa. No roughage has a greater general usefulness. Its content of mineral nutriment is at least among the highest, and it has the reputation of producing large bone in calves, colts and poultry.

It has been reported that dairymen who use slacked lime to sweeten the mangers after feeding corn silage have less trouble with sterility than do others who do not follow this practice.

The direct effect of protracted deficiency of mineral nutriment is malnutrition of the bones. This is common in swine, wherever exclusive cereal feeding is practiced, but, the country over, it is rare in cattle; that is, it does not commonly reach the acute stage at which it is recognized. It is reported, however, as quite prevalent in southern Alabama, and is said also to be found in parts of southern Mississippi, in Florida and in the state of Washington. In the Alabama situation the soil is sandy, and contains very little lime. The cattle are on the ranges where legumes, if present at all, are scarce. As soon as these cattle are put on velvet beans and other farm crops in the fall they recover and come out in good condition. Here it is noticeable that cows are more commonly affected than are suckling calves, but the disorder is not entirely confined to the cows.

This disorder has been found in a great variety of situations, but most commonly in regions of unfertile sandy soils, or soils of granitic origin, especially if these be worn by long cropping with insufficient fertilization.

We must not lose sight of the fact, however, in connection with the comparative rarity of acute malnutrition of the bones in cattle, that our anxiety is not especially to feed in such manner as

to prevent this malady, any more than our personal anxiety at mealtime is to escape death by starvation; rather, it is our desire so to feed our animals, as well as ourselves, as to maintain a maximum state of efficiency, which in the one case is as far removed from malnutrition of the bones as in the other from general starvation.

We have as yet made no experimental studies of the practical application of the results of this investigation, but from my present understanding of the matter I would offer the following suggestions to the dairy farmer.

Get your farm into a high state of fertility, and treat the soil, if necessary, so that it will grow legumes; then grow them, making as liberal use as is profitable of fertilizers containing calcium and phosphorus.

Consider with care your meadows and pastures; they are often neglected; if the soil is not rich, the mineral nutrients in pasture grass may be doubled by fertilization.

Build up the mineral reserves of your cattle by growing them largely on leguminous roughage or on pastures containing an abundance of legumes; and allow them exercise, as much as they incline to take. Muscular activity increases the avidity of bone cells for mineral salts. Malnutrition of the bones of calves is often due half to character of feed and half to confinement.

Feed leguminous roughage during milk production; and give the cow a chance to refund mineral overdrafts by continuing the liberal feeding of leguminous roughage during the latter part of the period of lactation, and during the dry period, before the birth of the next calf.

Use as large a proportion of roughage in the ration as seems practical and profitable.

If you are short of leguminous roughage and must depend on corn fodder, straw, or hay made from grasses, or if on any other account there is reason to believe that your cows are not receiving proper bone food, give them bone flour. If they are already in good order there will be no marked change in condition, but the feeding of bone flour will help to keep them at their best, and is good insurance.

We have not yet determined the best method of feeding bone flour. We have fed $2\frac{1}{2}$ ounces per head per day mixed with the grain, but it may be better, and all that is necessary, to allow cattle free access to this preparation. This I hope to learn at an early date.

The results of this investigation, therefore, do not indicate the desirability of radical departures from those methods of dairy cattle management which are practiced by the most successful dairymen, but they do illuminate the field in a way to add to our resourcefulness in meeting the exigencies of practice by rational and discriminating modifications of procedure. Furthermore, the facts, as we are finding them, contribute to the weight of evidence in favor of good general agricultural practice.

THE INOSITE PHOSPHORIC ACIDS OF FEEDING STUFFS*

By J. B. Rather

The organic phosphoric acids of the seeds of plants are of interest to students of agricultural problems from a number of standpoints. This is especially true of the salts of the organic phosphoric acids which contain inosite in the molecule and which are collectively grouped as "phytin."

The nature of the phosphoric acid in cottonseed meal and its alleged effect on hogs has been the subject of considerable study. Hardin, of the South Carolina station, believed that the principal phosphoric acid of cottonseed meal was pyro-phosphoric acid, and made the suggestion that to the presence of this acid was due the well known toxic effect of cottonseed meal on hogs. Many years later this work was taken up by Crawford in the U. S. Bureau of Animal Industry. He repeated much of the work of Hardin, and on the basis of experiments on laboratory animals concluded that the poisonous principle of cottonseed meal was without doubt pyrophosphoric acid.

It was shown, however, by the present writer that the compound believed by Hardin and by Crawford to be pyrophospheric acid was in reality an organic phosphoric acid containing inosite in the molecule. About a year later these results were confirmed by Anderson at the New York (Geneva) station. Experiments by other workers on animals also failed to support Crawford's theory, and at the present time this view is not held. It is interesting to note that at about the time Crawford was attempting to prove that the toxic principle in cottonseed meal was this phosphoric acid, workers at the New York (Geneva) station brought forward evidence to show that the phosphoric acid in wheat bran was beneficial to cows. The compounds of cottonseed meal and of wheat bran have since been shown by the present writer to be identical, and these results have been verified by later work.

From the standpoint of the agricultural chemist, it is of interest and of considerable importance to know the composition of this phosphoric acid. It has been known for a long time that an

*Contribution from the Arkansas Agricultural Experiment Station

organic phosphoric acid exists in the seeds of plants and that this acid yields inosite on hydrolysis with mineral acids. Various formulas have been proposed for this acid from time to time by different workers, and there has been little agreement in the results obtained and the conclusions arrived at. Posternak believed the compound to be anhydro-oxymethylene-diphosphoric acid, and considered that the inosite was a synthetic product of the action of sulphuric acid on the organic acid. Other workers believed that the acid was a complex of inosite and pyro-phosphoric acid, and still others thought it to be an ester of inosite and ordinary, or ortho-phosphoric acid. The presence of pentose in the molecule has been alleged by Anderson, but results by the present writer, and indeed by Anderson himself, offer no support to this view. Much of the earlier work along this line was done on materials whose purity and stability had not adequately been demonstrated. This accounts for the varying conclusions as to the nature of the acid to a considerable extent. In view of the ease with which inosite can be split off by acids and even by enzymes, it appears most likely that the compound (or compounds) is a simple ester of inosite and phosphoric acid. Until adequate evidence is offered to the contrary, there is not reason to assume a more complex composition.

Of course, if the synthesis of the acid could be effected, considerable light would be thrown on the nature of the compound. Contardi believed that the compound was inosite hexa-phosphoric acid and claimed to have made it synthetically from inosite and phosphoric acid. Here again the lack of adequate criteria of purity throws doubt on the work. Other workers could not verify Contardi's conclusions, and indeed claimed that the supposed compound of Contardi was a mixture. Anderson, at the New York (Geneva) station, attempted the synthesis also without success. From the synthetic standpoint then, the nature of the acid has not been demonstrated.

Making the most logical assumption, namely, that the compound or compounds, are simple esters of inosite and phosphoric acid, of which there are six possible, which compound predominates in the seeds of the agricultural plants? Once more the views of different workers are at variance. Anderson, who at first adopted the view that the compound had the composition ascribed by

Posternak, came to the conclusion that wheat bran contained an inosite-pentose-phosphoric acid yielding inosite phosphoric acid on hydrolysis and ascribed various formulas. The inosite-pentose theory having been shown to be without justification, he adopted the view that the inosite phosphoric acids are esters of inosite and phosphoric acid, and claims to have separated inosite mono-phosphoric acid, inosite triphosphoric acid, and inosite hexa-phosphoric acid from wheat bran, and inosite hexaphosphoric acid from other grains.

The present writer, in his work on cottonseed meal and wheat bran at first adopted a formula almost exactly twice that of inosite pentaphosphoric acid, and later in the examination of cottonseed meal, wheat bran, wheat shorts, corn, oats, kaffir, rice bran and rice polish, with improved methods of preparation and purification, came to the conclusion that the formula most nearly in accord with the composition of carefully purified and analyzed salts of the acid common to all of these products was that of inosite penta-phosphoric acid. Part of these results have been published and the remainder is now being prepared for publication. The conclusions of Anderson could not be verified on wheat bran even when the methods devised by Anderson were used. Boutwell, at the Wisconsin station, was also unable to verify Anderson's conclusions.

The present writer believes that much of the confusion in this field is due to the analysis of products prepared without adequate evidence as to purity, and, as is the case with the free acid, analyzed in a condition in which the necessary drying brings about obvious changes. Whatever may be the final verdict as to the nature of the inosite phosphoric acid, or acids, of plant products, there can be no doubt that concordant results by different workers will not be obtained until the purity and stability of the compounds subjected to analysis is demonstrated without reasonable doubt.

There is a possibility that the materials prepared by different workers are actually different members of the same group of compounds, and indeed this is probably true to a limited extent, as for example the separation of inosite mono-phosphoric acid and inosite tri-phosphoric acid from wheat bran by Anderson, and the separation of inosite tri-phosphoric acid and inosite penta-phos-

phoric acid from cottonseed meal by the present writer. It is possible that the composition of the acid is affected by regional influences and other factors not as yet understood, inasmuch as inosite triphosphoric acid separated by the present writer from cottonseed meal purchased on the Baltimore market could not be separated from Arkansas cottonseed meal even when the same method of preparation was used. Notwithstanding these possibilities, it appears to the writer that most of the differences in the results obtained by various workers in this field are due to improper methods of separation, purification and analysis.

It has been known for some time that inorganic phosphoric acid constitutes only a small part of the phosphoric acid of concentrated feedingstuffs. It has also been believed that the principal compound of phosphorus soluble in water or in weak acids is inosite phosphoric acid. Until recently, however, the best means available for determining the amount of this constituent was by determining the total soluble phosphorus and the inorganic phosphorus and subtracting the latter from the former. The assumption was made that the difference represented the inosite phosphoric acid, or "phytin" phosphorus.

The present writer has recently shown, however, that this variety of phosphorus compounds can be readily and accurately determined directly in plant products other than dried forage by titrating with ferric chloride under certain conditions. This method is not affected by non-phosphorized substances or phosphorized substances in the plant extract other than phytin, nor by certain other sources of error. By means of this method it has been demonstrated that, on an average, 86 per cent. of the acid-soluble phosphorus in concentrated feedingstuffs is of phytin nature, the variation being from 74 to 97 per cent. of the soluble phosphorus. It is probable that the bulk of the remainder is inorganic in nature. About 73 per cent. on the average, of the total phosphorus in the plant products examined was found to consist of this compound or class of compounds.

The bulk of the mineral element phosphorus, most indispensable to the animal body, is presented to the animal in the form of inosite phosphoric acid. Studies of the utilization of this substance by hogs are being made by the writer, and will be reported upon shortly.

Fayetteville, Ark.

ABORTIVENESS AS RELATED TO POSITION IN THE LEGUME

By Byron D. Halsted
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A failure of the ovule to develop into a seed is a common occurrence in the fruits of the Legumenosæ. It is the purpose of this paper to call attention to the fact that the likelihood of such an abortion depends largely upon the position that the ovule occupies in the pod.

During the past three years much attention has been given to a study of abortiveness in the pods of a few kinds of legumes, chiefly the larger-fruited sorts of the vegetable garden, namely, peas and beans, the plan being to connect this failure in subsequent studies with viability of seeds and vigor of plants produced from them.

The method of study is so simple as scarcely to need the stating. The pods are first assorted into groups upon the basis of number of ovules, that is, all pea pods of the same number of ovules are recorded by themselves. Each pod is shelled and the record made in squares of cross-lined paper, from which the percentages are derived.

CANADA FIELD PEAS

In this study 360 pods were used and the results are given in the accompanying table in percentage of abortiveness.

TABLE I

POSITION IN THE POD

Type of Pod	No. of Pods	Base	2	3	4	5	6	7	8
5-ovuled......	89	38.2	7.8	5.6	12.3	55.0	....	....	....
6-ovuled......	160	48.1	18.1	6.8	6.8	20.6	68.1	....	....
7-ovuled......	102	70.5	38.2	8.8	3.9	7.8	40.1	84.3	....
8-ovuled......	9	88.8	77.7	33.3	0.0	0.0	22.2	55.5	100

The table shows that the abortiveness is greatest in the tip position and next in the basal position and the least in the central region of the pod in all four types.

SOYBEANS

A study similar to the above was made in three kinds of soybeans, representing the early, mid-season and late sorts, namely, Early Brown, Ito San and Wilson. The combined totals for all three kinds are given below.

TABLE II

One Seeded Pods	Total	Two Seeded Pods	Total	Three Seeded Pods	Total
1-ovuled only	805	2-ovuled only	1481	3-ovuled only	947
2-ov., base abortive	315	3-ov., base abortive	391	4-ov., base abortive	9
2-ov., tip abortive	110	3-ov., middle abortive	127	4-ov., 2nd abortive	5
3-ov., base & mid. abort.	79	3-ov., tip abortive	50	4-ov., 3rd abortive	23
3-ov., base & tip abortive	24	4-ov., base & 2d abort.	1		
3-ov., mid. & tip abort.	4	4-ov., base & 3d abort.	2		
Total	1346	Total	2052	Total	984

From table II it is deduced that 26.2 percent. of the 4382 pods have one or more abortive ovules, and of these 1149 pods, 71.5 per cent. have an abortive basal ovule and 13.9 percent. are with aborts at the tip. In other words, in these soybeans there is a great preponderance of abortiveness in the basal ovules.

In an other study of the Wilson soybeans, involving over three thousand pods, it was found that in the two-ovuled pods the abortiveness was ninety percent. in the basal position, and in the three-ovuled pods the percentages from base to tip were, 79, 2, 14, 6 and 6.2.

A parallel study of the Ito San gave essentially the same results.

Another test was made with Ito San alone. In 2480 two-ovuled pods the basal position had 83.8 percent. of all the aborts and the tip 16.2 percent.

In the 7432 three-ovuled pods the basal position had 72.5 percent. of all the aborts, the middle 22.3 percent. and the tip 5.2 percent. In other words, the decrease of abortiveness was very rapid from the base to the tip.

BUSH BEANS—MOHAWK

The Mohawk may well be taken as the type of bush beans. In Table III are shown the results of the study of the point in hand of this paper.

TABLE III

Type of Pod	Number of Pods	Number of Ovules	Number of Aborts						Total	Per Ct.
			Base	2	3	4	5	6		
Three-ovuled.......	13	39	7	0	1	0	0	0	8	20.5
Four-ovuled.........	158	632	22	13	16	10	0	0	61	9.7
Five-ovuled.........	253	1265	34	15	11	10	7	0	77	6.1
Six-ovuled..........	121	726	28	1	2	2	1	1	35	4.8
Totals & Averages	545	2662	91					19	181	6.7

Table III shows that a plump half of all the abortiveness is in the basal position and that the amount diminishes from the base to the tip, where less than a tenth of the ovules failed to grow.

Incidentally, the table shows further that the abortiveness decreases from 20.5 percent. in the three-ovuled pods to 4.8 percent. in the six-ovuled pods.

DWARF LIMA BEANS

Two kinds of Lima beans were used for this test, namely, Henderson and Burpee, representing the two leading types. The Henderson, with its thin-walled pods and small seeds, yielded 39.4 percent. of pods with aborts, while the Burpee, with its thick fleshy pods and large seeds, had 60.8 percent. of pods with abortive ovules.

TABLE IV

PERCENTAGE OF ABORTIVENESS FOR TYPE OF POD AND POSITION IN THE POD

Type of Pod	Variety	Position					Average
		Base	Middle			Tip	
Two-ovuled......	Henderson.	22.0	......	......	......	3.7	12.8
Two-ovuled......	Burpee.....	44.8	......	......	......	8.6	26.7
Three-ovuled....	Henderson.	36.6	......	3.8	......	2.6	14.3
Three-ovuled....	Burpee.....	41.5	......	11.6	......	13.9	22.3
Four-ovuled......	Henderson.	33.8	6.2	......	.8	3.1	11.0
Four-ovuled......	Burpee.....	32.0	24.0	......	20.0	17.0	23.2

Table IV shows that both kinds agree in having much the largest percentage of aborts in the basal position and generally it diminishes from the base to the tip.

WISTERIA

This ornamental hardy twiner usually bears but a few pods and the records here given add a sidelight upon the results obtained from the annual plants grown primarily for their fruit and seed.

TABLE V

Type of Pods	No. of Pods	Number of Aborts							
		Base	2	3	4	5	6	7	Tip
Five-ovuled...	27	16	8	17	11	0	0	0	20
Six-ovuled....	215	159	123	131	113	109	0	0	137
Seven-ovuled.	121	100	86	84	70	60	65	0	68
Totals......	363	275	217		209		185		225

From Table V it is found that the abortiveness in the basal portion is 75.7 percent. and in the tip it is next highest with 62.0 percent. In the middle of the pod it reaches 57.5 percent. This shows that in pods that carry aborts, very generally the largest number of failures is at the base.

SCARLET RUNNER

The Scarlet Runner is an ornamental twiner that approaches the pole Lima bean in habit of growth, but the pods, as a rule, do not form seeds abundantly and for that reason was selected for this study.

From several hundred pods examined the following tabulation of abortiveness was secured.

Base	2	3	4	Tip	Average of All
14.4%	6.8%	3.2%	.28%	2.5%	5.5%

It is seen from these results that the percentage of abortiveness, starting high at the base, decreases rapidly until the tip is reached, where it rises again to near a third of the amount of that of the base.

The results obtained as shown above with a somewhat wide range of subjects all point in the same direction as regards the object of the test, namely, that the amount of abortiveness is connected with the position that the ovule occupies in the pod. The aborts are associated primarily with the basal position in all the subjects that have been studied, excepting the Canada Peas, in which the failure was greatest in the tip position and next at the base.

Further research is desired to fully determine the causes that act together to bring the observed results.

Studies are being made to determine whether the position in the pod is associated with relative size of seed, and whether viability of seed and vigor of seedling are correlated with position in the pod, with the hope of definitely locating in the pod the best seed for crop-production, and whether, in the same plant, size may be an index of such location and seedling value.

For example, the middle seed in the five-seeded pod may be the heaviest and the best one for crop production, thus leading to a more careful sifting of the seeds for planting.

Botanical Dept., New Jersey College Experiment Station.

THE MOST PRESSING AGRICULTURAL DEVELOPMENT PROBLEM IN THE UNITED STATES

Charles V. Piper
U. S. Dept. of Agriculture

Superlatives are notoriously dangerous words to use in serious discussions of agricultural as well as of other topics. Yet I have ventured to employ such in presenting a problem by no means new—in fact, one of the problems that investigators have often attacked with enthusiasm, but have quit in despair. The problem to which I refer concerns the vast area of undeveloped coastal plain land in the south, namely, all of that from Norfolk, Va., to Galveston, Tex., lying between the Piedmont area and the seacoast, excepting only the great alluvial thrust of the Mississippi valley.

The soils of this area are predominantly sands or sandy loams, and excepting the swamp lands are, or were, covered purely or largely with pine timber. In this area over a hundred soil types have been distinguished. Some of these are fertile and well suited to general farming, but most of them are too poor to be attractive, agriculturally speaking. It is not exaggeration to say that most of the land is poor, and much very poor.

The area of these lands is approximately shown in the following table:

	Population 13th Census	Total Land Area in acres 13th Census	Area Improved in acres 13th Census	Total Area in acres swamp
North Carolina	1,071,152	16,830,336	5,195,647	4,710,000
South Carolina	837,629	12,495,449	3,261,435	3,925,000
Georgia	1,317,678	23,126,722	6,529,871	3,450,000
Florida	752,619	35,111,040	1,805,408	17,580,000
Alabama	1,115,714	20,032,109	5,569,542	780,000
Mississippi	801,140	14,900,813	3,776,486	....
Louisiana	508,236	11,439,783	2,199,650	....
Arkansas	236,899	6,208,765	1,366,625	....
Texas	906,744	22,233,000	6,022,649	....
Total	7,574,811	162,378,037	35,727,313	30,445,000

Table giving, by States, the approximate population, total area and area of improved land of those soils of the coastal plain that support or did support a growth of pine. From the Thirteenth Census. The statistics on swamp land are from figures recently compiled by the Office of Public Roads and Rural Engineering. Somewhat more than a hundred soil types are represented in this area.

Excepting the swamp lands, which require expensive reclamation, most of the area was originally covered with timber, purely or predominantly pine. It is stated that about 76,000,000 acres of this timber have been removed, and this area presents the "cut-over pine land problem." In spite of many active efforts to bring about the agricultural utilization of this land, but little real success has been secured, and that mainly on the better types of soil. The area is being added to at the rate of about 10,000,000 acres a year, this representing the stumpage removed by the sawmills. It is purely a matter of mathematics to figure out when the last sawmill will close, if we assume merely that the present rate of timber removal continues. It would be difficult to find a more dreary sight than an abandoned sawmill town. But this is what awaits a vast area in the south until the land shall be devoted to some beneficial and profitable use. Unless the problem is solved soon, while the land is in possession of individual owners, much of the land, and the problem, will likely revert to the state, just as happened to some of the cut-over lands of northern Michigan.

Broadly speaking, four general types of farming have been developed on the southern pine lands, mostly with the aid of relatively large amounts of fertilizer. These are:

1. Truck farming.
2. Orcharding, particularly citrus, peaches, pecans.
3. Mixed-crop farming—cotton, corn, velvet beans, cowpeas, peanuts, etc.
4. Swine raising.

So far as trucking and orcharding are concerned, it must be admitted that only a small percentage of the acreage can profitably be employed for such uses. This acreage can increase safely only as the increasing population of the country provides markets for these products.

Mixed-crop farming will doubtless occupy most of the more productive soils. The main limiting factor is the relatively large expense needed for fertilizers. Numerous abandoned or neglected farms indicate that in many cases the existing conditions, both agronomic and economic, were too severe for success. In general, the efforts of the timber companies to sell their cut-over lands for general farming have not met with much success.

Swine raising is increasing rapidly in the south, many of the successful annual forages being very satisfactory for this purpose. There seems good reason to believe that the south can raise hogs more cheaply than the north; but much of the product will doubtless continue to be soft pork. Swine raising is however a relatively intensive type of farming, and will in itself not solve in any large degree the utilization of the cut-over lands.

These four types of farming show that the soils are productive under intensive farming; intensive particularly in the sense of using larger amounts of fertilizers than are elsewhere employed in the United States. The results indicate clearly that the tillable land will eventually be farmed when the increasing population of the nation furnishes sufficient economic pressure. This eventuality is, however, still so far distant that it offers but little encouragement to the present landholders.

Viewing the problem broadly, there seems no escape from the conclusion that the profitable utilization of these lands in the immediate future is not to be solved by any or all of the methods discussed. Two solutions seem possible, namely (1) reforestation and (2) cattle raising.

1. Reforestation

Data as to the returns that can be secured from reforesting the pine lands are very scanty. It is however undoubtedly true that if the land values be placed low enough, reforesting will yield a proper interest return. At the present time the land owners are but little interested in reforestation, nor are they likely to become so as long as there is a reasonable probability of an agricultural use being found for the lands. The untillable lands should doubtless be kept forested, and it is not unlikely that much tillable land may yield better returns from forest products than from any system of agriculture.

2. Cattle Raising

There has long existed a so-called live stock industry in the piney woods, the product of which has been very scrubby cattle and razorback hogs. These degenerate animals probably gave rise to the idea that the climate of the south is inimical to the raising of high quality live stock. Be that as it may, the work of every southern experiment station has shown clearly that the climatic factor is practically a negligible one; that with proper care and feed just as good animals can be raised in the south as in the north or west.

During the past few years several factors have conspired to bring about a great interest in the south in live stock. The main factor has been the boll weevil, which greatly reduced the acreage of cotton and compelled farmers to change from single-crop farming. Even if practical means of controlling the boll weevil be discovered, the increased expense will inevitably be to reduce the acreage. As much and more cotton will probably be grown, but mainly by increasing the yield per acre. On improved general farms the live stock produced will in all probability be mainly hogs.

So far as the large landholder is concerned, the principal impelling motives are the greatly increased value of cattle and the desire to secure revenue from his idle lands.

Under average conditions in the piney woods there is good natural pasturage from early spring to mid-summer; and fair pasturage from mid-summer to frost, during which the animals keep in good or at least fair condition Through the remainder of the year the animals simply exist. Two steps to better this type of cattle raising are evident and have already been adopted by the more progressive. First, the securing of good bulls to improve the stock. Degenerate, as many southern cattle seem, they grade up remarkably fast when good bulls are employed. Second, the growing of some feed to tide the animals through the lean season. This feed is commonly corn, sorghum, or Japanese cane, with a growing tendency to build silos. In addition, the velvet bean is important. The development of this crop during the past three years, or since early varieties have been generally available, has been remarkable. In 1915 the velvet bean crop occupied

probably not over a million acres, and these mostly in Florida. In 1917 there were approximately six million acres, nearly all grown in conjunction with corn. The utilization of this great increase of feed presents a problem, as only a fraction of the crop can be grazed by the available live stock, and with the scarcity and high price of labor much of the crop may be left in the fields to waste. In any event, the velvet bean has become a factor of the first magnitude in solving the problem of cheap winter feed for southern cattle.

This brings us to the most vital and difficult problem confronting cattle raising on the piney woods soils, namely, good, permanent pastures. Pastures furnish the cheapest of all forage, and success or failure with beef cattle is definitely correlated with good or poor pasturage. It has been said that the south is not a natural grass country. The implied argument is fatuous, as no timbered country is a "natural grass country" in the sense of the cattleman. The north was a timbered country, but with the removal of the forests the land quickly became covered with many introduced grasses, particularly blue grass, redtop, and white clover—all of European origin.

In the piney woods region of the south the scattered forest has a grass undergrowth composed largely either of broom sedges (Andropogon) or the various narrow, tough-leaved grasses locally called "wire grass," but consisting of species of various genera. Often broom sedge and wire grass occur intermixed. Numerous other grasses are present, but the two furnish most of the available feed. As pasturage they are fair during the growing season, but thereafter very poor. Such as it is, it is the basis of the existing cattle industry in the piney woods region.

Can these lands be economically put into a better type of permanent pasturage? In the south no such extensive grassing of the cleared lands with introduced grasses has taken place as in the north, except on certain soil types, under constant pasturing. On the Piedmont clayey soils Bermuda grass, nearly always accompanied by Japan clover, readily covers pastured lands. In the piney woods region, however, Bermuda acts thus only on the heavier or more fertile soils. On the sandy coastal soils, where the water table is shallow, carpet grass will, under continuous grazing, form a dense, nearly pure pasture. Bermuda grass and

carpet grass rarely grow together; one or the other occupies the land almost exclusively. In both types of pasture Japan clover is commonly present, and in many cases bur clover and narrow-leaf vetch can with some trouble be established. All of these are introduced plants.

On soils of comparable fertility Bermuda grass pasture has a higher carrying capacity than has blue grass. Carpet grass, on the other hand, probably has a lower carrying capacity, but for a longer period—as much as eight or even nine months under very favorable conditions. Where either kind of pasture can be established the pasture problem may be considered solved, except as to the most economic means of bringing about the transformation. Under heavy, continuous pasturing both broom sedge and wire grass give way, provided the creeping grasses will come in. This may be observed about any settlement in the region where the town cattle graze. In this case, however, the added fertility due to the manure may be a factor.

There are, however, extensive areas where neither Bermuda nor Carpet grass offers a solution of the problem. This is true on the sandy lands where the water table is not shallow enough, and also on the majority of soil types lying between the clays of the Piedmont and the sandy coastal soils. Some of these soil types are fairly good for general farming, but they are difficult to convert into permanent pastures with any grasses yet agronomically known. There still remains a vast field of endeavor to discover such pasture plants, provided they exist. Until all have been tested it is well to be hopeful. A few rather newly introduced grasses have been very successful in restricted areas, as for example Natal grass on the sandy hills of central Florida. Such examples encourage one to believe that the problem is not unsolvable. One conclusion, however, seems fairly clear, namely, that great areas of southern land can not be rapidly developed unless the pasture problem is solved. In the meantime many cattle companies have already begun operations. With the existing high prices for cattle they can succeed with the poor native pasturage supplemented by silage and velvet beans. Under normal conditions their continued success will almost certainly depend on the solution of the problem of good permanent pasturage. This is what makes the problem a pressing matter.

SOME FACTORS OF SUCCESS AND FAILURE IN DRY FARMING

By Alvin Kezer
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The title of this paper is somewhat general. The writer will take the responsibility of limiting the discussion, however, to dry farming as conducted on the high plains of eastern Colorado. This region has a minimum altitude of approximately 3,500 feet and a maximum altitude of nearly 10,000 feet. The great mass of this Plains area lies between the altitudes of 4,000 and 5,000 feet.

The rainfall is low, varying from a minimum of about eight inches to a maximum of about eighteen inches in the most favored portions of the region. The rainfall is subject to violent fluctuation, both above and below normal. When the fluctuations are above normal, cropping success is assured with almost any method of operation and farm management. When the rainfall, however, is fluctuating very much below the normal, only the successful worker survives. The years of 1911 and 1916 represented some of the extremely low fluctuations in rainfall.

If we take a region through the central portion of the Colorado Plains, which can be accurately defined on the map by location of towns from Colorado Springs eastward, namely, Falcon, Calhan, Limon, Stratton, Burlington, we find that the 1911 rainfall for this section averaged 7.65. In 1916, through the same region the rainfall averaged 7.38. The rainfall through the same points for the seasons of 1914 and 1915 ran above an average of twenty inches. These four seasons represent about the limits of fluctuation downward as well as upward.

Some portions of this region have been settled and depopulated two or three times in the past twenty-five years. Other portions have maintained a continuous settlement throughout this length of time.

In 1914, the Colorado Experiment Station started a definite set of farm management and enterprise surveys in the attempt to determine what farm methods enabled a man to stay on the land and to what extent farm methods were responsible for failures. Data were gathered in El Paso, Cheyenne, Lincoln,

Adams and Logan Counties, covering these points. The saying has been common for years that there is as much necessity for having a man adapted to dry farming as to have crops adapted to dry farming. How far this statement is borne out by records is indicated in the following data.

These studies showed the preponderating importance of crop acres per farm. Through the years which have been observed, the labor income which is used as a measure of efficiency in this case has been found to vary with the acres in crops. In presenting these data the exact labor income received is not reported in this paper, but a proportionate figure for the labor income is given in each case. In the five counties used, as the crop acres increased, the labor income increased in every instance.

Arranging the farms in groups according to the number of acres in crops:

In El Paso County, 57 farms were studied. Nineteen farms having a range of crop acres from 20 to 111, with an average of 82 crop acres per farm, returned a labor income equivalent of 64. Nineteen farms ranging from 112 to 172 acres with an average of 143 acres, gave a labor income equivalent of 91. And 19 farms ranging from 173 to 837 acres in crops, with an average of 287 acres, gave a labor income equivalent of 142.

In Cheyenne County, 49 farms were studied. Sixteen farms, with a range in crop acres of from 21 to 47, averaging 36, gave a labor income equivalent of 32. Eighteen farms, ranging from 48 to 86 acres in crops, with an average of 71 acres, returned a labor income equivalent of 55. Fifteen farms, ranging from 87 to 199 acres in crops, with an average of 128 acres, returned a labor income equivalent of 88.

In Lincoln County, 47 farms were studied. Fourteen farms, ranging from 10 to 100 acres in crops, with an average of 73, gave a labor income equivalent of 37. Sixteen farms, ranging from 101 to 200 crop acres, with an average of 160, gave a labor income equivalent of 54. Seventeen farms, ranging from 201 to 420 crop acres, with an average of 261, gave a labor income equivalent of 99.

In Adams County, 57 farms were under observation. Seventeen farms, with a range of from 10 to 72 acres in crops, with an average of 46, gave a labor income equivalent of 34. Eighteen

farms ranging from 73 to 100 acres in crops, with an average of 87, gave a labor income equivalent of 66. Twenty farms ranging from 101 to 304 acres in crops, with an average of 154, gave a labor income equivalent of 106.

In Logan County, 67 farms were studied. Twenty-one farms ranging from 35 to 180 acres in crops, with an average of 114, gave a labor income equivalent of 61. Twenty-two farms ranging from 181 to 259 acres in crops, with an average of 221, gave a labor income equivalent of 140. Twenty-four farms ranging from 260 to 880, with an average of 460, gave a labor income of equivalent of 248.

A study of these figures bears out the statement previously made that the labor income increases as the number of acres in crops increases. In other words, the factor from the standpoint of farm management, which has been of greatest importance and which has been uniformly working throughout, has been to increase the number of acres put into crops.

Other figures show that one animal unit requires about the same amount of labor as one acre of land, and while the best success under dry farming conditions is attained by a proper balance of live stock and crops, it is easily possible to get too much live stock. The best ratio of live stock to acres in crops is not uniform from year to year, but for the number of years studied, it is shown that there should be at least eight acres in crops for each animal unit. Stated in another way, the maximum results may be obtained by having about eight crop acres to each animal unit in the business.

A special study on this factor was made in Logan County from a slightly different angle. Logan County was chosen for the special study because the settlements being studied were old and well established, having been farmed in many instances, for over twenty-five years. A study was made of this section, based upon the length of residence upon the land. The first classification showed that the labor income was highest for those farmers who had been on the land from 7 to 10 years. Farmers in the class of residents 15 to 20 years were making slightly lower labor incomes than the class 7 to 10 years, and the class 10 to 15 years. This caused us to try to determine the business factor behind this effect.

Further study revealed the fact that the reason for the group of residents 7 to 10 years having a larger labor income than the group 15 to 20 years, was due to a better balancing of live stock and crop acres. At the then prices, the group of farmers who had been longest on the land was operating with too many animal units in proportion to their crop acres. While the group of residents 7 to 10 years was operating at about the best possible ratio.

A further study of this problem showed that the substituting of prices which has prevailed three and five years before the study was made for then then prices, would have reversed the situation and have brought the group of residents 15 to 20 years above the group 7 to 10 years.

As strange as it may seem, the highest labor incomes have not come from the farms having the heaviest yields. Excessively heavy yields under dry farming have usually been produced on very small acreages at a heavy expense in time and labor. The largest labor incomes have been produced where *good* yields were obtained on considerable acreages. Under the very best dry farming conditions the yields on some of our acreages are not sufficient to make a large labor income because they are not sufficient to make a large business. It is for this reason that the largest labor incomes are made by increasing the number of acres in crop. Increasing the number of acres in crop may slightly reduce the yield, but it makes a larger business and a greater assurance of success.

Figures have already been shown which indicate that the labor income is increased almost in proportion to the number of acres in crop. Similar studies show that the labor income also is almost in exact proportion to the number of crop acres per man and the number of crop acres per horse.

Leaving out of consideration, then, the factor of climatic conditions as an element in success or failure, we can lay it down as a definite rule that the question of success or failure from the standpoint of the farming business is based primarily upon the ability of the manager to get the highest possible number of crop acres, and to get the highest possible number of crop acres tended per man and per work horse.

It is also highly essential to keep a proper balance between live stock and acres in crops. A great proportion of the crops

which may be grown successfully on the dry lands must be utilized through live stock. The exact proportion of live stock to acres in crop will vary with fluctuations in seasons and markets. As has already been said, the best proportion of the years under study has been about eight crop acres per one animal unit.

Over most of the dry land region, good farming lands cannot be profitably owned and grazed in a state of raw prairie, because the amount of feed furnished by these virgin lands is not sufficient to pay income to the owner. But the owner can afford to put the land into crops, produce sufficient live stock to utilize those crops which cannot be marketed otherwise, and return in average years a fair income on the investment and labor involved.

The average crop value is a fluctuating factor, but for the years studied the average crop value per acre was low throughout the region under investigation, as is indicated by the following table:

County	No. of acres studied	Value per acre
El Paso	9,742	$11.20
Cheyenne	3,855	10.10
Adams	5,424	14.90
Logan	18,301	14.00
Lincoln	7,865	10.00

Throughout this region the average value per acre amounts to $12.30. The average return per animal unit for the same region is $10 per head, which would leave an advantage of $2.30 per acre in favor of the crop acre.

Putting the conclusions of this last discussion in the shape of a general statement, we can state that live stock is essential. The maximum number of crop acres is essential. That is, proper adjustment between live stock and the crop acres is essential. This adjustment will vary in different localities. The practice should be to devote all the time possible to the production of crops and to keep enough live stock to consume and furnish a market for all crops that cannot be marketed as cash with any degree of certainty.

A PROSPECTIVE NEW FORAGE PLANT FOR THE IRRIGATED MOUNTAIN VALLEYS OF THE NORTHWEST

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In all new agricultural countries the farmer's first problem is to subdue the native sod and replace nature's crop by something of greater economic value. The soil is generally rich, and quite free from weeds. By the adoption of crops best suited to the climatic conditions, provided an ample water supply may be secured, good crops are possible for many years. Sooner or later, however, the farmer runs against two difficulties if he continues to grow grain exclusively upon his land. A reduction in available plant food reduces his crop yields to the point of vanishing profits and weeds also cut into these profits by increasing the amount of labor necessary to get a crop, or they may even crowd the crop out altogether.

In any system of farming, therefore, the farmer is finally compelled to grow soil enriching crops or to apply home produced or artificial fertilizers. Such crops will also help to control the weeds, but experience has taught us that we cannot master them completely without a bare fallow or summer tilled crop. In many parts of the United States, corn, beans, potatoes or sugar beets furnish the cultivated crops that may be grown on a large enough scale to fit into a rotation system. We are, however, too far from market to grow potatoes in large areas, and beans and corn are not adapted to our high altitudes. They are too uncertain and too small in yield to be grown to advantage.

Another problem was to find a forage crop that would yield a high tonnage under our conditions. In the lower valleys, alfalfa is the large yielding forage crop and it does very well in most of the high valleys, as does clover, but these alone would not control the weeds.

Some four years ago some of our extension men visited a farmer in the northwestern part of the State—the Flathead Valley—who was growing Russian Sunflowers, which were very large

producers of forage. He suggested to our agronomist that he believed this plant had possibilities as a forage plant under Montana conditions. Acting on this suggestion in the summer of 1915 a small area, about one-tenth acre, was planted to sunflowers in our experimental field. The crop was planted in rows some three feet apart and grew immensely, producing over thirty tons of green feed per acre. The crop was cut and put into the silo, which was being filled with clover. It was put in when the silo was about half full so that there was clover both above and below the sunflowers. During the winter it was fed to our dairy cows which ate the sunflower silage as readily as they did the clover silage and seemed to do just as well upon it.

The next season (1916) we planted three acres of the sunflowers, planting in rows about thirty inches apart. The crop was not irrigated though some sub-irrigation water was available from seepage. The crop grew well, stood nine to ten feet tall, and yielded about twenty-two tons of green feed per acre. We started to feed the sunflowers to the cows the latter part of August. They were run through an ensilage cutter and fed green from the field. The cows ate the forage readily. For comparison, we divided the cows into two lots and fed green corn to one of the lots. The cows on the sunflowers ate this forage just as readily as those getting corn and maintained their milk flow just as well. This test was continued for some three weeks. The sunflowers remaining were put into the silo and fed during the winter to both cows and fattening steers. Samples were taken of the green forage for chemical analysis, but the destruction of our chemical laboratory also destroyed these samples and prevented the chemical studies contemplated last year. The results of the feeding test were very satisfactory, however.

Some fear was expressed that the sunflowers would taint the milk so the milk from the cows getting the sunflowers was kept separate from that produced by the cows getting the regular feeds. Our dairyman could not find any difference in flavor as a result of the feeding of the sunflowers. In other words, he guessed wrong as often as he guessed right in picking out the milk of the cows fed the sunflowers.

The past season we planted seven acres to the sunflowers. Again the crop did well, growing eleven or twelve feet high and

yielding close to twenty-five tons of green forage per acre. We repeated the feeding comparison with the green corn as a soiling food and with equally as good results as the year before. We have this year filled a one hundred and twenty-five (125) ton silo nearly full of sunflowers and have planned this winter to repeat the test of last year. We have also taken samples for chemical analysis.

Two facts, I believe, we have demonstrated; first, that the Russian sunflowers make a satisfactory forage for cattle, whether fed as a soiling crop or as ensilage. Next, it is our largest yielding forage crop, producing fully two and one half times as much forage as will corn in our high valleys, and more than twice as much as clover for the season. It is moreover a crop that can be cultivated and later so thoroughly shades the ground that weeds get a very poor chance to grow. It has one drawback in that it must be run through an ensilage cutter before it can be used to advantage as forage for cattle, and can only be cured in the silo for winter use.

We have yet many points to study as to the best method of growing the crop and with what other forage it is going to combine to give the best results. We are also trying out the crop on the dry lands in various parts of the State, to determine its value, under those conditions. We are not as yet urging farmers to grow the crop largely, but merely asking them to try a small area to find out how it yields, and those who have ensilage cutters can also try it as a forage for cattle. It is worthy of a trial by other experiment stations which are located as we are in a high mountain valley.

HOW FARMERS ACQUIRE THEIR FARMS

W. J. Spillman

Former generations of American farmers acquired their farms mostly from the public domain at very little expense. Under the conditions that then existed tenant farming could not very well become a problem, for a young man with a little capital could, by moving a few days journey, acquire a good farm of his own; hence there were few tenant farmers. But agricultural land in the public domain is largely exhausted now and the rising generation of farmers finds it necessary to acquire farms in a different manner. Tenant farming is increasing and is becoming a problem with which we must begin to deal.

In order to ascertain the facts as to the methods pursued by present farm owners in acquiring their status, the Office of Farm Management is conducting an investigation into the history of some 10,000 farm owners and tenants, mainly in the North Central group of States. The data for this study are now practically all in hand, but only a small portion of them have been tabulated. I cannot attempt to deal with the entire mass of data available, but merely to give some sample results to show the general trend of affairs.

Table No. 1 gives the stages through which 417 farm boys passed in becoming owners of farms in the State of Illinois. It shows the proportion of these owners who acquired ownership by the various methods found in the study. 24% of these owners passed through the complete series of stages as follows: Laborer on their father's farm, hired man on other farms, and tenant, before they became owners (See Table No. I). 36% of them had skipped the stage of hired men, going out from their father's farm to tenantry and later to ownership. Data not given in the table show that the average age at which the first group left their father's farm was about eighteen years. The second group remained at home about three years longer, in return for which the father provided them with the working capital necessary to become tenants. It will later be seen that the second group

saved about a year and a half, as compared with the first group, in the time required to pass through these stages. The third group represents men who skipped the tenant stage, but passed through the hired man stage. They constitute only 8% of the total. 32% of these farmers remained on their father's farm until they themselves became farm owners.

It will be noted that those owners who passed through all four of the stages acquired their farms mostly by outright purchase, only 2% of them having inherited their farms, 9% having married farm owners, and 15% having bought their farms from their father or other near relative.

TABLE I

How 417 Farm Boys Became Illinois Farm Owners

(Steps (1)	Totals	% of Grand Total	Inheritance %	Marriage %	Purchase From	
					Father % (2)	Others %
O. T. H. F.....	100	24	2	9	15	74
O. T. F........	150	36	23	3	36	38
O. H. F........	33	8	..	45	15	40
O. F...........	134	32	58	7	22	13
Grand Total.	417	% of G'd Total	27	9	25	39

(1) O=owner; T=tenant; H=hired man (on farm); F=laborer on father's farm.
(2) Or other near relative.

In the next group, where the young men remained longer on their father's farm, 23% acquired ownership through inheritance, 3% by marriage, 36% by purchase from near relatives, while 38% bought outright from others. In the group who omitted the tenant stage, 45% obtained their farms by marriage, 15% by purchase from near relatives, and 40% by purchase from others. Of the last group, consisting of young men who remained still longer on their father's farm, 58% inherited their farms, 7% acquired them by marriage, 22% by purchase from near relatives, usually the father, while only 13% bought from others.

Taking the entire group of 417 owners, 27% inherited their farms, 9% acquired them by marriage, 25% by purchase from near relatives and 39% by purchase from others. It will be noted

that of the individuals in the various groups who acquired farms by inheritance the percentage acquiring farms by this method increases largely with the length of time the young men remained on their father's farm.

By far the largest percentage of any group acquiring ownership by marriage is found among those who skipped the tenant stage. It was the fact that a large proportion of these men while they were still hired men married the daughters of successful farmers, which enabled them to skip the tenant stage, nearly half of the hired men who acquired ownership directly having done so in this manner.

Table No. I is confined to those owners who were brought up on the farm. A small proportion of owners was found who had come from other occupations, but the numbers are too small to give significant averages. Some were found, however, in each of these four groups.

Figure No. 1 shows how long each of 72 farm owners in Kansas worked as hired men on the farm before becoming tenants. The average length of this period for these 72 men was 7.56 years, but it is seen that the norm of the frequency curve is somewhere between 4 and 5 years; that is, the major portion of these men became tenants after 3 to 6 years experience as hired men, 4 and 5 years being the most frequent length of service in this capacity.

Figure No. 2 shows the length of time each of 195 Nebraska farm owners spent as tenants before acquiring ownership. The average for the entire number is 10.4 years, but the mode of the curve is from 4 to 10 years.

Under the conditions which prevailed at the time these men passed through these various stages it would appear that the usual course for a man of good fiber, starting out without capital, was to become a hired man at about 18 years of age. By the time he was 22 or 23 years of age he had saved enough capital and acquired sufficient credit to enable him to begin as a tenant. After from 4 to 10 years work as a tenant farmer he was able to acquire sufficient capital to make an adequate first payment on a farm of his own. Generally speaking, these men marry at about the time they become tenants and by the time they are 30 years of age they have acquired ownership, usually with a mortgage.

When the full data obtained in this study are published many more facts of interest will be given. I have attempted here to give only a few salient points.

NUMBER OF KANSAS OWNERS WHO REMAINED HIRED MEN FOR YEARS INDICATED.

72 OWNERS AVERAGE 7.56 YRS

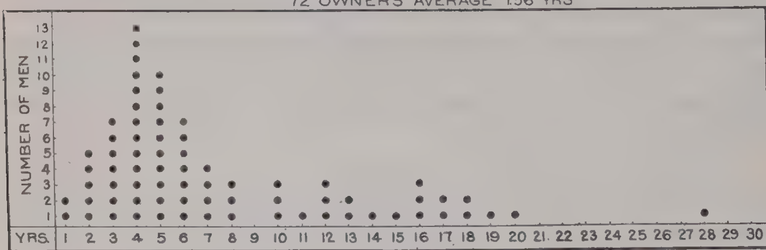

FIGURE 1

NUMBER OF NEBRASKA OWNERS REMAINING TENANTS FOR YEARS INDICATED.

195 OWNERS AVERAGE 10.4 YRS.

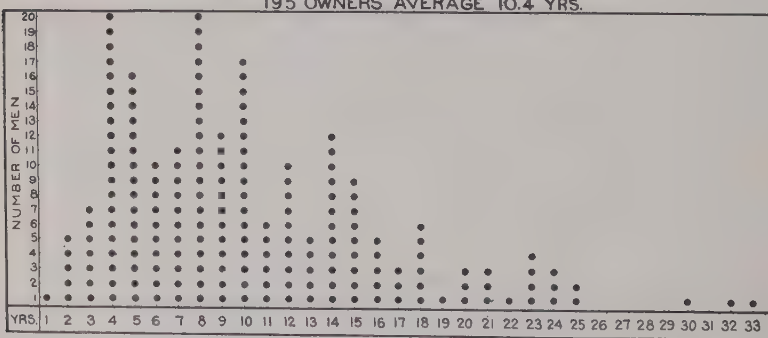

FIGURE 2

PROMOTING PRACTICAL FORESTRY WORK

F. W. Rane
Massachusetts State Forester

Results in any field of endeavor comprise the standard of value that ultimately is recognized. Theories, discussions and printed suggestions are of little avail until they are put to the practical test. The lack of co-ordination that has prevailed between so-called book-learning on the one hand and the practical, or school of experience, on the other is largely accounted for by the fact that theoretical advice has not been sufficiently put to the actual test before being offered to the public. Ultimately, the true balance, or the combining of the theoretical and the practical, will be reached, but during the uncertain stage a great amount of marking time prevails.

From his experience the writer greatly desires to emphasize the fact that the best way to overcome prejudices is to insist on the theoretical ideas being first practiced so that the necessary elements of danger, or latitude for risks, may be determined. To be more specific, in Massachusetts, for example, for a number of years, the State Forester stood ready to aid any citizen of the State with advice, and even to go so far as to furnish forest working plans for treating woodlands. Much of this advice was never carried out, and in some instances, even where it was, it did not prove satisfactory. In the latter case, the trouble was largely due to the fact that the persons executing the plans had little conception of the essentials necessary to success. If trees were marked to be taken out in a thinning by an expert, they were then chopped or sawed down by some local person in the same manner that had been customary in clean cutting, the results from such a practice being that the unmarked trees which were left for future investment were, as chance would have it, more or less ruined. Undoubtedly, the trees cut were gotten out at the least possible expense, and it could be construed as a practical operation, but the larger or real purpose sought was absolutely

*Read before the Society for the promotion of Agricultural Science, at Washington D. C., Nov. 13, 1917.

destroyed. The practice of thinning woodlands has been a hard pill for operators accustomed to clean cutting to swallow. It often takes a decade to change from one well established custom to another, even if ultimate results can be convincingly shown at the time. Again, weakness on the part of a state forester or his assistants in the past has been in the commercial end. Men who do not have to meet the weekly payrolls for labor and expense of machinery, teams, and tools are less inclined to give this side of the problem as much consideration as it deserves. Estimates, therefore, have at times not "panned out," and even good explanations and excuses do not replenish the original figures. In forestry operations the technical forester makes his gravest mistake in overestimating. His enthusiasm and great desire to interest and aid, together with his inexperience in numbers of actual operations and commercial dealings, often brings about a negative rather than a positive result. In a practically new profession, as that of forestry in America, perhaps this condition of affairs is to be expected. A young men can in a relatively short time receive and absorb the technique in forestry, but it takes much longer to acquire sufficient ripe experience so that he has the confidence of his abilities. The dependence generally placed in a lumber operator or woodsman of experience, which often is mellowed with many years of hard knocks as well as success, is due largely to one's confidence that such experience must be had for dependable success. Such men are generally cautious, and as a rule purposely underestimate, knowing well that they will receive commendation rather than criticism in the final results. Generally speaking, the writer is of the opinion that the average practical operator is prone to be too conservative, while the trained forester is, if anything, too liberal in his estimates.

Problems in Massachusetts needing solution where neither practical woodsmen nor technically-trained foresters were successful, namely, the handling of a great amount of depleted woodland territory in the eastern part of the State devastated by the brown-tail and gypsy moths required heroic measures.

The whole solution pointed to one of utilization. At about this same time, the chestnut blight struck our chestnut forests, and here again was a similar problem which resolved itself down to the same question of utilization. The forests under considera-

tion included all conditions, but were largely of mixed stands of hardwoods which had been stripped of their foliage by the insects and were in all stages of decline from those with dead tops, or so-called stag-headed, to those actually dead. Many of these stands were in proximity to and actually on beautiful old country estates. The growth was of all sizes and ages.

To utilize this great conglomeration of material, and at the same time make it self-supporting, was the problem. It was a sheer question of finding a market for the product to be cut. A technical man who had had more or less practical training as well was engaged for the diagnosis. A study showed that the product could not all be cut into cordwood, as it would glut the market. Other uses were suggested, and finally the only practical way left open was to go directly into the portable saw-mill operation business and cut the trees according to the various uses and dimensions required. This procedure has been in operation in Massachusetts now for four years. The State Forester's Department has been really compelled to go into the lumber business; otherwise nothing would have been done. It is believed we have taken a step forward in promoting practical forestry that is unique in itself. The State does not own the portable mills, nor is the capital involved in operations taken from the State treasury. The State Forester's Department outlines and estimates the costs and the owner of the property furnishes the capital. The State Forester furnishes the supervision, but the foreman of the operation, who is a man previously trained in the Forester's department, together with the mill owner, who is contracted with by the thousand, the choppers, maintenance of camp, equipment, etc., are all paid for from the fund furnished by the owner. Every part of the operation to the sale and delivery of the product is looked after, even to reforesting or underplanting, until the whole operation is complete and the final account settled by the State.

During the past four and one-half years, this work has resulted in our cutting approximately 6,800,000 bd. feet of lumber, 28,000 cords of wood, and over 25,000 ties and poles. When it is realized that little, if any, of this work would have been done had not the State Forester's Department initiated and carried it through, it is believed to be well worth while.

The only expense the State has been to is the expense of one assistant, who devotes his whole time to utilization. He spends only enough time on each operation to see that it is properly set up and is kept running economically. The success of the whole matter is in keeping costs low, and in turning out forest products for which there is a demand at fair prices.

The real value to the State, and the State Forester's department, is that besides the benefit from utilizing the product, it keeps the department in close touch with the commercial and practical side of forestry, which every state forestry department must have to be of the greatest assistance to both producers and consumers.

From our Massachusetts experience, it is believed that more real interest and accomplishments can be had in promoting practical forestry work when the department keeps in actual working touch with the practical operations and commercial activities of the industries as well as in the position of adviser.

Every state forester should have a forest utilization man who makes it his business to keep first-hand information on the business and operating end, thereby strengthening the state work.

HAVE THE AGRICULTURAL COLLEGES FULFILLED THEIR OBLIGATION IN THE PRESENT WAR EMERGENCY?

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It is eminently proper that this Society, which is peculiarly a child of our Agricultural Colleges, should consider at this time, when nearly the whole world is torn asunder by the most terrible war known to history, this subject, at its annual session. The older members of this society, who founded and nurtured it through its earlier years, have also been leaders among the great builders of our agricultural colleges.

The subject might perhaps be better stated—"Has our system of agricultural education met its obligation and stood the test in the present war emergency?" for I wish to include, in the work done, the United States Department of Agriculture, the Farm Bureaus, and other co-operating agencies, Boards of Agriculture, and would also wish, did time permit, to pay all due respect and regard to other institutions which have contributed and are contributing so much. The Federal Department, the Colleges, the Stations, and the several Extension Agencies all comprise a vast system, hardly yet in working order, but living together as brothers and sisters in the same family. Time allotted for this paper, however, permits only a brief survey of some of the things which the Department and the Colleges, with their co-operating organizations, have done during the last few months to meet the War Emergency. Achievements which I mention here can no doubt be duplicated, multiplied and surpassed by striking instances in all sections of the country, so I have made no attempt in this paper to cover the whole field.

I beg the question from the beginning by assuming that these colleges do have a tremendous obligation in the present crisis, and that they have met nobly and most satisfactorily these unforeseen conditions so suddenly thrust upon them. The scope and duty of these institutions have been set before this society more than once in familiar quotations from the Morrill Land Grant Act, but I found a short time ago, a different, and to me a

more impressive statement by Mr. Morrill himself in the report of the United States Department of Agriculture for 1867. It reads as follows:

> "There shall be established in each state at least one college, upon a sure foundation, acceptable to all, but especially to the sons of toil, where all the needful sciences for the practice of the avocations of life, shall be taught; where neither the higher graces of classical studies nor that military drill our country now so much appreciates will be ignored, and where agriculture, the foundation of all present and future prosperity, may look for troops of earnest friends, studying its familiar and recondite economics, and at last elevating it to that higher level where it may invoke comparison with all the most advanced standards of the world." (Page 317, Annual Report, U. S. D. A. 1867.)

Conceived just prior to the Civil War, and championed in the very heat of the struggle, this bill had injected into it two things which appear to have been of equal importance in the minds of its supporters. First, scientific and technical education, and second, education of young men in military matters, who might render their country efficient service in any future emergency. Indeed, military training is placed before technical education in the wording of the bill.

Abraham Lincoln, standing not far from this very spot, signed this bill on one of the blackest days of the Civil War—a day when the Union armies were suffering one of their greatest defeats. Those who know have told us that the idea that these colleges should serve this country in times of war as well as peace was foremost in Mr. Lincoln's mind at that time. It is of a system of agricultural education and of these colleges founded on such ideals as are here expressed that we now ask this question.

For fifty years the progress of these institutions has, when viewed from one standpoint, been rather slow, but when the fact has been taken into consideration that they had little for a real foundation and background to begin with, their growth has been extremely rapid. They have lacked funds, they have lacked experienced men, they have lacked a science of agriculture, and they have in many cases not had the support of those who should have been most zealous for their welfare. Some of these things were about overcome, and these institutions were beginning to come into their own, when almost in a day and without due

preparation, the responsibility of providing for a nation equally as unprepared, plunged suddenly into war, was thrust upon them. Agricultural science was in a day pushed forward a half century. Research projects have either been suddenly headed up to fit emergency conditions, or else the work, as in many cases, is at a standstill because the men have left for other work. Information collected through many years must be crystallized for immediate use. Methods of getting existing information to the people, and state and national policies regarding the production, conservation, and use of necessities had to be developed by our Extension Services over night. Central authorities had to take the responsibility for putting forth drastic policies which would not only take care of our own country, but would help other nations to survive also. These colleges had to "make good." How they and the Federal Department set about to do, it can be best shown by giving a few instances.

The United States Department of Agriculture, after carefully studying the needs of this country, and of our allies, after determining what our normal production would be, has prepared and organized all over the country nation wide campaigns for wheat, corn, cattle, sheep and swine production. Efforts have been made to conserve breeding stock, to maintain equable relationships between feed and animals, and not to upset normal and proper farm practices. The colleges, through their extension systems, have been the organizers and initiators of these movements.

There are tremendous preventable losses in production which ought to receive much more attention than we have been giving them in the past. Federal officials estimate that losses occur in our livestock industry from such disease as tuberculosis, hog cholera rabies, anthrax, and others, and those from predatory and noxious animals which amounts to millions of dollars every year. About one-half the carrying capacity of the range is destroped by rodents. Our great staple crops also suffer much from the attack of diseases and insect pests.

The loss of fertility from manure amounts to more than $1,000, 000,000 annually and lack of equipment on farms, waste of time and labor, not adapting crops to conditions, lack of working capital, poor planning, poor seeds, losses fron poor judgment in marketing, and many others, which cannot be exactly estimated actually

amount to billions. It is estimated by federal authorities that our present crop and animal production of approximately $19,000,000,000 could be raised to at least $25,000,000,000 were these preventable losses stopped. It is astonishing what can be saved in this connection at a comparatively small expenditure of money by organizing proper preventative and control measures.

Great as these losses are, how much greater would they be were it not for the discoveries in our Federal laboratories and in our stations of effective methods of controlling these pests, and the successful application of these over a wide range of conditions. Improved seeds, a scientific study of soils and their requirements, the discovery of serums and antitoxins, finding new materials and devising methods of application, are the means by which we can maintain even our present production and degree of control which we now enjoy. No one can discount the work which the United States Department of Agriculture and our Agricultural Colleges have done in these lines. These colleges have sent forth men who are leaders in the world of scientific research work in Federal, State, municipal and private laboratories. They have had to supply their own teachers, but these have been able to instruct students so that they have taken leading parts in many world-wide movements. These men have also contributed much to secondary schools and industrial education.

Today graduates of the engineering departments in these institutions are in the front rank among Army engineers, in automobile and aeroplane plants, in farm implement shops and factories where agricultural products are transformed into food and material for our great industries. These men are doing a signal service for our country in war emergency work.

Graduates from the veterinary science schools of these colleges have always been indispensable to the building up of animal husbandry in the regions where they have been located. The United States Army now has thousands of these men in its service.

These colleges have been the first training grounds of thousands of doctors, lawyers, members of the other professions, and of farm boys who have later become captains of industry. The man on whose shoulders rests the responsibility to-day in the

Council of National Defense, for keeping up adequate transportation facilities in this country was a student in an agricultural college.

The Home Economics departments through their graduates have changed standards of living. Food values have been taught. Household conveniences have been more generally adopted. When it becomes necessary to restrict the diet of a nation, hundreds of women teachers in, and graduates of these colleges are the ones who are putting the conservation programs through. Recently the responsibility of organizing food conservation work in cities has been added to the duties of these colleges.

Commercial concerns dealing in commodities largely used in agriculture, such as insecticides, fertilizers, feeds, foods, etc., have been built up on the work of chemists graduated from these agricultural colleges. All of these play a prominent part in war preparedness.

Definitely planned increased acreages of staple crops have been secured by agents of these institutions working with farmers. When accurate information as to seed, fertilizer, or labor needs, or the relative status and condition of the dairy, poultry, swine or sheep industry has been needed, surveys have been made and the results tabulated for immediate use.

Hundreds of thousands of cattle and other live stock have been removed from drought stricken regions to regions of plenty, thereby conserving these animals either as breeders or as a part of our food supply.

The garden movement—back yard, vacant lot and factory employe—has been developed through the well organized club work system. Pig, poultry, sheep, calf, canning and other clubs have been fostered. Factory owners, big business men and city dwellers have turned toward these institutions as never before for aid in developing agricultural and garden enterprises.

College Presidents and members of the faculties of these institutions have taken prominent places on State Councils of Defense, and on food committees. In a few instances college officials have been made State Food Administrators.

Too much can not be said of the value of the lines of Extension work, which have been developed in nearly every state during

the past ten years. Through this it has been possible to reach adults and juniors alike. In all of this propaganda work the county agent has been the key man. He has been asked to perform nearly every conceivable kind of labor, and is today the most popular, the most overworked and at the same time the most criticised man in the system. Without him it would have been impossible to carry out this emergency program. The system reaches out from Washington into every state, to nearly every county, and to thousands of homes of the nation.

These colleges have upheld and are upholding the military honor of the nation. At the time of the Civil War, one college, the Michigan Agricultural, had just graduated its first class and it is to the honor of that institution and of these men that, with the exception of one man, every member of the graduating class enlisted. This College had 68 officers in the Civil War and 43 in the Spanish-American War. Each year between 1861 and 1898 men from these colleges have received commissions in the regular army. At the time of the Spanish-American War, full volunteer companies were furnished by the Colleges in South Dakota, Kansas, Idaho and Missouri. Others were organized but were not needed. The University of Tennessee was represented in this war by 3 colonels, 3 majors, 3 staff officers, 5 captains, 14 first lieutenants and 21 second lieutenants. Three hundred men enlisted in 1898-1899 from Cornell alone. Twenty-nine institutions furnished 439 commissioned officers in the volunteer army and 38 in the regular army at that time. (Figures from Dabney, Rep. O. E. S. Cir. 40, page 279). I have attempted no exhaustive study of all institutions and no doubt do some colleges great injustice by not mentioning them in this connection.

I wish we had accurate statistics of the men from these colleges who are at this time in the military service of this country. I have not attempted to compile any figures. You know as well as I that we can number them by the thousands in Infantry, Cavalry, Artillery, Engineering, Ordnance, Quartermasters, Aviation, Hospital, Naval and Red Cross Service. Reserve officers' training camps have hundreds of these men. This sudden mobilization of our military and naval forces during the last few months would not have been possible without the training these men had received during their college courses. The men sent out from these

colleges are mobilizing armies and drilling men as well as leading in the movement to provide food and clothing for the most of the world.

How much service can be rendered by an institution in a few months is shown by the record of one of these colleges. Last February a Public Safety Committee had been organized in the state, but no attention had been given to the problem of the food supply. The State College was instrumental in getting together a few prominent persons to serve as a food supply committee. Within four days' time, the committee had met, county and town committees had been appointed, a tentative program had been adopted, and definite instructions as to a policy on the food supply situation were being sent through county agents to every town in that state. Farm production was speeded up, over-production of uncertain crops and possibility of marketing others were considered. A sane program was advocated. Local communities were organized to look after local needs. Seeds, farm labor and fertilizers were secured. Garden work, community, factory and individual, was encourgaed. People in the cities were taught gardening through demonstration gardens and by individual instruction. Home and community canning and conservation were demonstrated and encouraged. Surveys of agricultural industries were made. Extra extension workers were furnished to assist in the production and conservation of food, and in the control of injurious insects and diseases. The State food committee was assisted constantly. Other non-agricultural colleges were assisted to mobilize their forces. Local community markets were established. The amount of literature prepared and sent out was greatly increased. Hundreds of demonstrations were given. Dozens of training schools for leaders were held in all sections of the state and at the college. The whole state caught the idea and the results in added production and better organization have been very evident and most gratifying. The state realized the worth of these things and contributed liberally.

There was little confusion. The system already organized worked. No new machinery was necessary, but more workers were added to take care of the increased calls for assistance.

The college of this state literally turned itself, with all of its resources, over to the service of the state. By the last of May

97% of its students were in some kind of emergency work; 25% of those enrolled last year went into military or naval service; 311 men went on farms; 60 took up gardening; 26 became community garden supervisors; 6 went into munition factories and 4 into ship building. All but about a dozen members of the faculty were pressed into emergency work. The work has not stopped. It goes on through the winter, and plans are already being made for better work next year.

These are some of the things one college did. No doubt others did more. It's a sample though of how a college attempted to meet war emergency problems when these were put up to it by the state.

While we may feel that our colleges in all their departments and relationships have been quite severely tested during the past few months, yet the real test of their usefulness is still to come in the larger problems which we shall face after the close of the war. Nothing is normal. Our entire social and economic structure has already changed. People are not thinking in the same terms as they did a year ago. A new order of things is upon us. We weigh things with different values. I heard a prominent man say the other day that "The nation which was really victorious in the war would be known twenty-five years hence by the progress which it had made and in the way that it gathered itself together." These colleges must face problems of greater production, better methods of farm management, better rural organization, improved sanitation, better balance between production, distribution and marketing and changed social conditions. The great leaks and losses mentioned must be stopped, and they must lead in the construction of a rural civilization and citizenship such as no country has yet known.

In defining what conditions lead up to this greater agricultural progress and prosperity, Hon. Isaac Newton, United States Commissioner of Agriculture, said in his report for 1862, that:

"The essential conditions are Peace. A continued and increasing demand for agricultural products both at home and abroad. An increased respect for labor. A more thorough knowledge and practice of agriculture as an art and science, and finally, more thorough education of our farmers in the physical sciences, in political economy, in taste and general reading.'

In the fifty-five years since this was written, these colleges have stood for these principles and have brought forth many others. The time is ripe to promote any further advancement desired, for business, commercial and professional interests have come at last to realize in this present crisis the real importance of agriculture to the nation's welfare. The colleges certainly can not dodge nor side-step these great issues.

There is a great danger which these colleges and the entire system of agricultural education is facing at the present time, and that is the failure to recognize that to allow conscription or false ideas of what constitutes patriotism; to break up organizations essential to the carrying on of agricultural enterprises and to take the crop of students already half way through their college courses, are some of the worst things that could possibly happen. England learned her lesson in the beginning of the war. We are in danger of making the same mistake which she made. Young farmers essential to greater production are being taken from our farms. Members of extension services, indispensable to the carrying on of food production, are leaving their work; the Bureaus of the Federal Department have been depleted of scores of their most promising younger workers; those in our colleges who should be training for responsible positions five years hence are not there. The most discouraging thing about the whole matter is that vacant places are not being filled with good men. The people generally hold the false notion that, "for the honor of our country," a man must don a uniform. Little credit is given the young fellow who has the courage to remain on a farm, or at his post in college or factory. You can hardly blame red blooded fellows if they do enlist for army or navy work.

We hear on every hand that "Food will win the war," yet, so far, no one has seen fit to place agricultural students in the same class with those of medical or dental schools, so far as excusing from military service is concerned, and until a few days ago it has been impossible to secure any pronouncement as to what the policy of the country would be regarding the keeping of young farmers on farms or our federal and state organizations from being badly disorganized.

President Wilson in his appeal to the country last April said:

> "America must furnish food and all other war supplies not only for herself but for all the nations at war with Germany. People who devote their energy to these things will be serving the country and conducting the fight for peace and freedom as effectively as the men in the trenches."

These colleges have always been patriotic institutions; they have held up ideals of citizenship and service; they have trained such men as we need in time of war. The vacant places on our college staffs and the small enrollment at many agricultural colleges this year are the best evidences I can offer of this spirit.

Dr. W. L. Broun, of Alabama, in his annual presidential address before the Association of Agricultural Colleges and Experiment Stations in 1891, begged its members to:

> "Consider the relationship they hold to the present and future well-being of this country, and whether working with retort, microscope, pruning or dissecting knife, they were working to ameliorate the conditions of human life, and by showing how better to subdue the earth to bring increased happiness and prosperity to the homes of the people, they were not working for themselves but for the good of humanity."

Any one familiar with what these agricultural colleges have done for this country during the past ten months I am sure can not justly deny that they have met their obligations in this war emergency. They have been broad in their sympathies, generous with funds and human effort, co-operative in their spirit. They represent American civilization and are doing their part to preserve that civilization. The fruit of these colleges—their men and women—are among the leaders who mobilize and drill armies, and provide food and raiment for most of the world. They face the future, realizing that they will have a mighty part to play in the reconstruction movements which will come when war ceases. These colleges have stood the test; they have met their obligations, not perfectly, but as well as institutions plunged suddenly into abnormal and unforeseen channels could. Their research men, their teachers, their alumni and their students have made good and the nation has a right to feel that these colleges will remain for years to come the centers of a dignified, stable and permanent plan for rural organization and development.

PRODUCTION AND CONSUMPTION OF WHEAT IN TIMES OF PEACE AND WAR.

Harry Snyder
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When the Imperial German Government considered her treaty with Belgium "a mere scrap of paper," and sent her army across that plucky little country, the world was harvesting a wheat crop of 3,600,000,000 bushels, a little more than 75,000,000 bushels above a ten-year average. The wheat crop of the United States was large—twenty-five per cent. of the world's total—which with Canada's crop made a yield of 1,050,000,000 bushels for North America. Russia, that land of feast or famine, had produced that year, 1914, a large crop, three-quarters of a billion bushels, or twenty per cent. of the world's supply. But Russia's surplus wheat was unavailable to the rest of the world.

France, under intense cultivation of small farms, produced 282,000,000 bushels of wheat, about twice as much as Germany and but little less than the combined yield of Germany and Austria-Hungary, where the rye crop exceeded that of France by a half billion bushels. Germany is more dependent upon rye for her bread than she is upon wheat, and grows three bushels of rye to every bushel of wheat, while in this country twenty bushels of wheat are produced to every bushel of rye, and heretofore only a small portion of this rye has been used for bread.

For some time prior to the war Germany had been accumulating gradually stocks of flour and wheat and other cereals. To allay suspicion, some of these stores were cached in the smaller surrounding countries to be reshipped to Germany. In the spring of 1914 there was a large surplus of wheat in this country, but by midsummer it had reached a low point because of being shipped abroad. It is now quite plain why this large reserve was drawn upon, for under ordinary commercial conditions with a new and cheaper crop of large proportions about to be harvested, and no

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Read at the 1917 meeting of the Society for the Promotion of Agricultural Science, November 13, Washington, D. C.)

shortages of wheat to be made good there is no hoarding of grain. According to the natural laws of merchandising, when a new crop supply is soon to be available, old, high-priced stocks move slowly. The reserves thus accumulated by Germany were soon exhausted. She supposed the war would be of short duration. This method of procedure in getting ready for war by hoarding stocks of grain is as old as war itself.

For many years England's wheat crop has been small. She has not had, like France, the large number of small farms producing wheat under intense cultivation. After the war broke out some of the large game preserves of the nobility were turned into wheat fields, and the first year the crop was increased 10%. Since then it has been still further increased until now the home production of wheat has become an important factor in England's bread supply.

The devastation of war decreased France's wheat crop about 25,000,000 bushels in one year and since then the decline has been very much greater. During the early period of the war the wheat and flour imports exceeded the decrease in home production, but the time has arrived when France as well as the other allied countries need a larger supply of wheat and other cereals.

Italy generally produces from 170,000,000 to 200,000,000 bushels of wheat, while her corn or maize crop is more than 100,000,000 bushels. Since the war her crops have been maintained well up to the average. This year's crop, is short. Italy consumes more maize than any other of our allies, and happily we are in a position to supply this cereal. Durum wheat and its products, as Semolina, have been large import items.

Scarcity of labor, lack of fertilizers, with other causes incident to war, have reduced wheat yields among most of the warring nations. In this country last year climatic conditions were unfavorable in the large winter wheat regions, but from many fields which late in March gave little or no promise, a fair crop was harvested in July and it would have been a little larger if there had not been too great haste in plowing up unpromising fields early in the spring.

Fortunately the total wheat crop yield of this country will exceed some of the early estimates, and Canada has a large crop. Argentine and Australia have promising crops. A considerable

portion of last year's Canadian and Australian wheat has not been marketed. Wheat supply is now largely an international transportation problem. As wars of large magnitude and long duration in the past have been attended or followed by famine, many have been greatly concerned as to our condition and that of our allies as regards the bread supply. While every possible saving of wheat and flour must be effected, and the per capita consumption of wheat in this country must be reduced, happily such saving will place us several laps ahead of the spectre famine. Extensive plans carefully made and executed are necessary to secure large wheat crops next year and to build up a reserve for either peace or war. Conserving our present supply and enlarging and improving future crops are pressing problems.

Wheat consumption cannot be unduly curtailed by all nations in war times. When other foods become scarce and high-priced more bread is consumed. There is no substitute for bread. The average consumption of wheat among the allied nations is greater than in the United States where more of a variety and higher priced foods are consumed. This is but natural with the larger income of the wage earner. Prior to the war, Belgium's per capita consumption of flour was equivalent to more than seven bushels of wheat, that of France about seven and of the United Kingdom about six, against 5.4 bushels in this country. Hence a wheat shortage is more severely felt by the Allies, accustomed as they are to consuming more bread and less other foods, than by the United States. While with us other cereals can be used liberally in the dietary many of the European countries have had so little experience with maize and oats as human foods that they are not in a position to make the best use of them. It is difficult at any time to change the fixed food habits of a country, but especially in war time.

The value of wheat in feeding a war ravaged people is well set forth in a report by Mr. Robinson Smith of the Commission for Relief in Belgium. In discussing the rationing of ten million people in Belgium and Northern France during the first two and a half years of the war, Mr. Smith says: "Wheat is above all else *the* food to be purchased for a starving population. It is cheap to transport, easy to discharge, its calorific value is high, it is well balanced as between protein and carbohydrates, and needs

only fats (butter spread thinly) to make a balanced ration; as flour it preserves well, its by-products are valuable for cattle and people are used to it, and were there a choice, all would demand an increase in their bread ration (if below normal), rather than the addition of some other food."

The basal ration fed consisted of 340 grams of bread, 300 grams of potatoes, 60 grams of rice, 50 grams of peas and beans, 25 grams cerealine, 30 grams of bacon, 20 grams of lard and 20 grams of brown sugar. It contained 44.8 grams of digestible protein and yielded 2,000 calories. The bread contained 22.3 grams of digestible protein and yielded 790 calories. That is, half of the protein and 40% of the calories were supplied by the bread. The ration cost 39.1 centimes (about 7.8 cents), and the bread about 15.3 centimes (3.06 cents). At the time the report was prepared wheat appears to have been selling at 50 to 75 per cent. of its present price. As subsequent events proved, it was a scant ration, tuberculosis increased and children particularly were undernourished. The difficulty seemed to be largely too scant an amount of nutrients rather than lack of variety of foods. Forty-five grams of digestible protein and 2,000 calories, costing about eight cents were "just enough to keep body and soul together."

In the feeding of the Belgians the per capita consumption of wheat was reduced from more than seven to about four bushels per year, and the other foods were reduced in even larger amounts. The bread used was made from 82% milling of the wheat. In discussing the flour and bread Mr. Smith says: "It is frequently stated that gray bread (so-called standard or 'entire wheat' bread, 82 per cent. milling), is more digestible than white bread. The opposite is very distinctly the case, as proved by many experiments in America, Germany and England." Then follows a list of references. "Indeed so much less digestible is gray bread than white, and often so much weaker in the value of its nutrients, that in many cases if 100 pounds of wheat are ground at 82% and bread (gray) made from it, that bread will have less nutritive value than bread (white) made from grinding 100 lbs. of the same wheat at 72%."

"The burden of proof is altogether on the side of standard bread enthusiasts who seldom quote analysis and digestion figures. Moreover by grinding at 82% we are reducing by 30%

our offal supply for cattle, pigs and poultry, which can digest it far better than we."

As one examines Mr. Smith's report with his pronounced statement in favor of white bread, but with the actual use of the gray (82% milling), one is inclined to ask: Why was the gray used? From what we have since learned of German military methods and of the Belgian Relief work carried on by tolerance of the Imperial German Government, it is quite likely that any good white flour sent into Belgium would have been exchanged for the inferior wheat-rye, potato-mixtures used by the Germans, as was done in parts of Northern France. The Germans never would have permitted the Belgians to be fed better bread than was used in their army.

The work of the Commission for Relief in Belgium emphasizes the value and importance of wheat for a war-famished people, and the reason why we should conserve our wheat for the use of our allies.

War increases the demand for bread, and to meet the additional requirements by accelerating wheat production is both a national and a world problem, and one not easily solved. Scarcity of labor, lack of fertilizers and other adverse factors have to be overcome. Although wheat production is largely dependent upon favorable climatic conditions, the shortages arising from unfavorable weather in one locality can be made good by producing wheat over wider areas. There has never been a time, except in our early history before the western states were settled, when the wheat crop has been a failure in all parts of the country the same year. Hence, the importance of raising wheat everywhere it will grow. Wheat has ceased to be a pioneer crop raised only on virgin prairie land. The time has come now when it must be systematically produced on farms where it was once grown and then abandoned.

Many of us recall Sir William Crooks' presidential address before the British Association for the advancement of science in 1898, when he predicted that wheat consumption would overtake the world's wheat production about 1931, unless improved methods of agriculture were inaugurated including the use of fertilizers, particularly nitrates. He says: "Thirty years is but a day in the life of a nation. Those present who may attend the meeting

of the British Association thirty years hence will judge how far my forecasts are justified." At the time of Sir William's address the initial steps were being taken to perfect the processes for fixation of atmospheric nitrogen by the use of strong electric currents, and he predicted that the nitrates produced by synthetic processes would be the chief source of nitrogenous fertilizers for wheat lands, and urged that these chemical industries be developed as soon as possible because of their great need.

As one re-reads this remarkable address after a lapse of nearly twenty years, it is plain that it was not intended as a "calamity howl" as some supposed at the time, but was meant to emphasize the great value of this new-born nitrate industry. Sir William Crooks believed man was too dependent for his daily bread upon primitive methods of cultivating virgin soils that would soon decline in productiveness. He characterized wheat as "The most sustaining food grain of the great Caucasian race" and it was his desire to stimulate wheat production so that there need be no curtailment in bread supply. It is interesting to note that sixteen years later Sir William at the age of eighty, while serving as one of the ordnance experts of the British Munitions Board, advised enlarged and improved methods for the manufacture of munitions, which advice if it had been adopted by the Government would have placed England in much better position to meet the great war in which she so suddenly found herself engaged.

Our country has either consciously or unconsciously adopted two of Sir William Crooks' fundamental ideas and they have been incorporated in our National Food and Defense Acts, namely, the provision for importation and use as fertilizers of large amounts of nitrates, and the erection of Government factories for the synthetic production of nitrates to be used both as fertilizers and as the basis of munitions. When this industry is established we will be better prepared for either peace or war.

While the use of nitrate fertilizer cannot be regarded as a panacea for all wheat culture troubles, as unproductiveness of soils which may be due to lack of other elements of plant food than nitrogen, or to various adverse soil conditions; nevertheless it is a step in the right direction, for low wheat yields on poorly managed prairie farms, also poor quality of the wheat, are often due to lack of available nitrogen. There should be a nationa

potash industry developed and sustained by the Government as well as a National nitrate industry. Then with our large natural supply of phosphates, complete fertilizers could be produced cheaply and abundantly, and fertilizers and munitions alike be made as conditions might require. Cheaper fertilizers are necessary for producing larger food crops.

As frequently noted the average yield of wheat in this country is too low. Our experiment stations have repeatedly demonstrated the value of good seed, better cultivation of the soil, systematic crop rotations, use of fertilizers according to a soil's needs and the harvesting and care of the crop as it should be. If the farmers of our country would only put into practice the knowledge collated by our experiment stations, the wheat yields of this country would be very much larger and the cost of production greatly reduced.

The quality of the wheat as well as the yield needs to be improved. Many of the old wheat lands have become foul with weed seed. Much could be done to improve the quality of the wheat by simply cleaning the seed and selecting the medium and heavy-weight kernels. Some weed seeds are very difficult to separate from wheat and they greatly reduce its milling value. Many flour mills are constantly increasing the machinery for removing weed seeds and other impurities from wheat. Much of the machinery is expensive and adds to the cost of the flour. Federal grading will probably be a factor in improving grain qualities as it will stimulate the production of better grain. Second and third rate wheat should not be advocated or extensively grown in localities that have an established reputation for the production of well-known and high quality wheats. Improving the quality of wheat is a very promising research line for investigation. There is a very close relationship between plant food supplies and wheat quality.

When the war is over, when Hohenzollernism and its ideas of "kultur" have been scrapped and all economic affairs are re-adjusted to a peace basis, first attention will be given to the larger production of foods. Wheat production is now a war-stimulated industry and like other industries it will be subject to readjustment to a peace basis. At first heavy demands will be made on bread stuffs as they are produced more cheaply and

quickly than meats. The American wheat farmer will again meet the wheat producers of other countries in the world's markets. How will we be prepared to meet competition after the world's war is over? Let us glance briefly at some of the other wheat producing countries.

Russia, with a better government in time, we hope, with an improved agricultural system and enlarged transportation and marketing facilities, will become a greater factor in the world's wheat supply than prior to the war. Parts of Siberia and Manchuria, which are much like the Canadian Northwest in soil and climate, will be producing more wheat. Already Manchurian wheat is being milled in Japanese flour mills and brought to America. The large game preserves of the nobility of England, which have been put into wheat, will probably continue its production. Canada will grow more wheat and her loyalty to England during the war has been such as to receive first consideration by England in the future. Argentina is slowly improving her agriculture. These are conditions that the American wheat producer will meet in the future. All the nations will be demanding cheaper bread. Therefore, now is the time for the American farmer to put the wheat industry on a sound basis. A maximum yield at a minimum cost of production will be the solution of the problem. Low wheat yields and high cost of production generally leave a small margin of profit and add to the expense of the consumer's loaf.

The American farmer should anticipate and be prepared to meet these changes that sooner or later will follow the war. Wheat production will change from a war-stimulated to a peace-competitive industry. This change can best be met by improving the methods of wheat production. There is no other cereal that can take the place of wheat and its value has been particularly emphasized by this great world war in which bread has become the very center of every nation's dietary. It is now very clear why Sir William Crooks designated wheat as "the most sustaining food grain of the great Caucasian race." Not only for the immediate future, but for a longer period, great possibilities are offered to the American wheat producer. He needs, however, the right kind of help and encouragement to place his wheat culture on a permanent basis.

It is most unlikely that the American people will go hungry for bread so long as available supplies of wheat are held on farms for higher prices, as any necessary additional legislation would be enacted commandeering wheat the same as other war necessities. The nation's problem is to win the war and no one can stand in the way by withholding necessary supplies.

Another phase of the problem is the utilization of the crop to the best advantage. To enable the present wheat crop to go as far as possible for bread-making purposes, various war breads have been proposed. By war bread is usually meant a bread made from wheat flour containing a part of the wheat offal, such as the 82 per cent. extraction flours previously mentioned, alone or combined with various cereals preparations. Emergency or so-called war breads, are made from a mixture of white flour and different cereals, but they are not the war breads used in the war-stricken countries. The chief ingredient of these emergency breads is wheat flour to supply the gluten which can be obtained from no other cereal than wheat except rye to a limited extent. The addition of any appreciable amount of foreign material to wheat flour lowers the bread-making value, and the loaf possesses lower physical properties than the white bread because some of the constituents have no bread-making quality. Being of poorer physical properties than ordinary white bread, many people may soon tire of these breads, therefore, I believe along with the advocacy of such breads encouragement should be given for a wider use of all cereals in the dietary in other ways.

By the voluntary use of emergency breads the saving comes mainly through restricted use of bread. When bread is poor one naturally eats less of it, provided other foods can be obtained at not unreasonable prices. Many people would prefer to eat less good bread and more cereals in other forms, as oatmeal, fried mush, "Johnny cake," barley grits, rice cake and other preparations rather than to attempt to include these as a part of the bread and thereby wheat flour is conserved just as effectually. In the advocacy of emergency bread alone as a means of conserving wheat it is a question if it might not result in a restricted rather than an enlarged use of other cereals, due to the consumption of but little of these cereals in the poorer bread and the feeling that in trying to eat such bread the individual has

done "his bit" to conserve wheat. Wheat flour should be conserved in not only one way, but in every possible way. The conserving of wheat flour has been attended with difficulties, because at present it is the cheapest cereal. If other cereals could be made proportionately as cheap as wheat flour, greater conservation results could be achieved as it would then be an economical measure and would appeal to some gastronomic patriots.

In the use of other cereals in the dietary to conserve wheat, barley is particularly worthy of consideration. In its general composition it resembles wheat more closely than any other cereal except rye. While bread cannot be made from barley alone because it contains no gluten like wheat, it blends with wheat flour better than the other cereals. Much experimental work is being done in the milling of barley, and it would seem that it would soon pass the experimental state and barley flour would become a regular commercial product. When that time comes the miller and the malter will compete for the barley crop, and it will become an issue as to whether barley shall be used for bread or beer.

The National Food Administration has been in operation for so short a time that all of the regulatory measures in regard to maintaining fair food prices and to prevent hoarding have not been as effective as they presumably will be later. In the case of flour and bread there is no question but that the work of the Food Administration has stabilized prices and held them within reasonable limits. Every assistance possible should be rendered Mr. Hoover in the difficult work of Food Administration.

The compulsory universal use of graham, whole-wheat and gray flours has also been advocated as a means of conserving the wheat crop. It is argued that ten per cent. or so of the wheat by-products can be added to the flour and the wheat crop made to go that much further. This theory is based upon the assumption that the flour with the added wheat offal is pound for pound equally as valuable for purposes of nutrition as the ordinary white flour, and that no appreciable returns, as human foods, are now obtained from the offals. Let us consider the matter. Graham flour is wheat meal. If graham flour were used there would be no offal available for cattle feeding. Extensive digestion trials by the U. S. Department of Agriculture have shown that

while 88 per cent. of the protein, and 91 per cent. of the energy of white flour are available as food, only 75 per cent. of the protein and 82 per cent. of the energy of graham are available as human food. The human is able to digest and utilize only a small part of the wheat offal. In fact, 100 pounds of white flour furnishes more nourishment than 100 pounds of graham, because the latter having the lower degrees of digestibility. The wheat offals, as bran and middlings, are very valuable animal feeds and they make excellent returns in meat and milk, foods which we cannot dispense with in our dietary.

The question as to the best use of the wheat offals then resolves itself into this form: Shall man try to utilize them directly and secure a low return or shall they be fed to animals which have greater powers to digest and utilize these feeds. When one looks at the problem from every angle it will be found that in case of a limited supply of wheat, the greatest returns are secured when man uses the flour and the domestic animals the feed part of the wheat, and then to supplement the wheat flour with other cereal products as barley flour, corn meal or oat meal. For example, barley flour is a better human food than wheat offal, and in turn wheat offals are better animal foods than barley flour. The same statement would also hold true of many other cereals. Hence it is more economical in the end to look to other cereals to bridge a short wheat supply rather than attempt to use graham flour. Long extraction flours like graham have not proved a nutritional success in any of the nations where they have been tried, and many of the warring nations have had to abandon graham flour.

As to the so-called 82 per cent. or whole-wheat flours, they furnish more nourishment, pound for pound, than graham, but less than the white flours. The term 82 per cent. extraction is indefinite in that an 82 per cent. product does not necessarily mean a flour of a distinct character or composition. When 10 per cent. of the offal is added to flour, more than a hundred and six pounds of the resultant product are needed to furnish the same food value measured in digestible protein and calories as 100 pounds of the white, as has been shown by extended tests of the U. S. Department of Agriculture and extending over a period of ten years.

In discussing the relative merits and demirits of whole-wheat and white flour some inconsistent comparisons are made as to their digestibility in acid pepsin solution, and then without qualification of "digestibility," leaving the impression that the results represented human digestion trials. As pointed out by Woods and Merrill the natural and artificial digestibilities of the graham, do not lead to the same conclusions and they suggest that this difference might be due to the fact that the coarser bread is retained in the digestive tract of man a much shorter time than the white bread and hence is not so completely absorbed.

In assigning a nutritional value to bread and other cereals it has been suggested that the proteins of each and all be considered of equal but of lower value than the meat proteins. Such a classification is imperfect as it fails to recognize that glutenin and other wheat proteins have equal nutritional value with the meat proteins and much higher than other cereal proteins as the zeins from maize, which are deficient in certain animo acids as lysine and tryptophane essential for nutritional purposes. Classifying wheat proteins as of second rate nutritional value is also imperfect as a second rate protein cannot take the place of a first rate protein, and over half of the proteins of wheat belong strictly to the first class.

It is stated by some that white flour is the product of the modern roller mill and that the flour made by the mill stone process was a whole-wheat flour and had the same composition as the wheat from which it was made. This is a mistaken idea; bolting cloths for removing the bran and wheat offal are known to have been in use for more than two centuries. A letter from General Washington to his miller at Mount Vernon has an interesting historic bearing on this point. He wrote to Mr. William Pearce in 1782 as follows: "My Superfine flour and fine flour always wait for directions from me to be sold, but the middlings and the ship-stuff you will dispose of whenever you can get a suitable price and your want of money may require." The ship-stuff and the middlings as mentioned in Washington's letter were separated from the fine flour and hence did not form a part of the flour as so many assert in claiming that old mill stone flour was a whole wheat flour from which nothing had been extracted.

While whole wheat may add desirable bulk to some rations, it may add excessive bulk where generally cheap, valuable, bulky vegetables as cabbages, turnips, beets and potatoes form a liberal part of the ration. Because wheat offals supply roughage in a human ration is no reason why they should be ground with and form a part of all flours and the offal sold at flour prices. A mixed diet is necessary. No food by itself—not even milk—is a perfect adult diet. A single food is only one dietary component. McCollom has shown that no grain, or for that matter mixture of two or three cereals alone, makes a perfect ration; and that incomplete nutrition follows if an animal is fed the floury part of the cereal alone, or the seed envelope alone, or a mixture of the two as present in the cereal itself. Recognizing this established basic principle, claims for superior merits as to unknown dietary components as so-called "vitamines" for either whole-wheat or white flour cannot be made as each in a way and by itself, like all other foods, is imperfect. I do not believe that the term "vitamine" will occupy a permanent place in science. It would have had a better standing if such excessive claims had not been made for such an indefinite substance, and if the process for its separation and manufacture had not been patented and exploited by a pharmaceutical company of Manheim, Germany. No tests appear to have been reported where the so-called "vitamine" compound or mixture has proved to be the deciding factor in cases of human malnutrition. There are unknown food components that take a most important part in the nutrition of man, but they cannot be inscribed within the limits of a "vitamine theory." Our knowledge of the composition of foods is so recent and so limited it is not at all surprising that there are unknown food components. We shall probably know more about this subject in the future.

Also it has been argued that whole wheat flour is superior to the white because of its supposed larger available phosphate content. However, the fact of the case is, ordinary wheat flour contains about five times as much phosphates as human milk, which can not be considered as failing to supply its quota of this material. Indeed it is a question if an excess of phosphates with insufficient lime and basic matter as is characteristic of all whole cereals, might not lead to nutritional disturbances. An excess of protein or carbohydrates in a ration is known to be injurious, and

the question can well be raised as to the possible effects of an excess of phosphates with insufficient basic material. Sir J. B. Lawes, many years ago considered an excess of phosphates, as in the case of whole-wheat meal flours, as very undesirable.

As to the best way of utilizing the wheat supply, I believe it can be made to go farther by grinding it according to the ordinary process of modern, exhaustive milling, which separates completely the flour from the offal, than by milling in any other way. Recognizing as we do that a varied and mixed diet is a necessity, white bread has advantages over whole-wheat bread. In a mixed diet containing white bread ordinary bulky vegetables as potatoes, cabbage, spinach and carrots can be used and furnish a better roughage than bran or wheat offal. In such a mixed diet the maximum available nutrients are secured from the wheat and the indigestible wheat offal is utilized by domestic animals, which have stronger powers of digestion than man. Thus the feed part of wheat, which would be lost if it were attempted to utilize it directly as human food in the form of graham and whole-wheat products, is converted by animals into valuable human foods as meat, milk and eggs. Modern flour milling I consider of the greatest economic importance as a food conserver.

THE STATIONS PART IN WINNING THE WAR

B. Youngblood
Texas Agricultural College

We have entered a world war for democracy of nations and the betterment of humanity. Victory will be won not by soldiers and sailors alone, but by the combined efforts of every branch of our government, backed by the loyal services of our various industries, and individual citizens as well.

If there is any one branch of industry that is in position to render more essential service at this time than any other, it is agriculture; and if any one class of citizens is in position to add more to the success of our cause, it is the farmers. Production must be accelerated and made more prolific in every manner possible in order that we may feed and clothe our soldiers, sailors and civil population, and in large part, those of the nations with which we are allied in a common cause. In this great undertaking, the Agricultural Experiment Stations are to play a fundamental part. Just as the army must depend upon our inventors to create newer and more effective weapons of destruction, so must the farmers of the country depend upon the agricultural investigators of the country for newer and more efficient methods of crop and live stock production. Just as the soldier must learn the use of new weapons as they are invented, so must the farmers of the country learn to put into successful practice the findings of the experiment stations. And just as the soldiers must have drillmasters and leaders, so must the farmers have leaders to show them how to put experiment station ideas into working harness on the farms.

It is fortunate indeed for the country at this time that the farmers are more receptive than ever before to the teachings of the experiment stations, as conveyed to them through our bulletins and extension workers. Only a few years ago the farmers of the country were in a very different frame of mind. Then it was not uncommon to hear a farmer say, "Your station work only tends to increase production. I can produce more now than I can find a market for. Give me a market and a remunerative price and I

will be content." Fortunately for the stations, no such argument can now be made. In those days there was practically no organization among farmers either in production or in the distribution of farm products. Through the activities of extension workers employing station knowledge, such a type of diversification has come into practice that feed, food, and fibre crops are produced more nearly in proportion with world requirements. Our knowledge of marketing has been greatly enhanced and our marketing practices have accordingly improved. Under these conditions the farmers of the country are becoming more grateful recipients of station information than ever before. We are all fighters, now, and of course extend a welcome to any aid or assistance which tends to make us more effective agents in our particular spheres. The soldier welcomes the development of a new gun. Likewise, every farmer who is a patriot, welcomes any information which in this time of shortage will enable him to produce more economically and in greater abundance.

The part which the stations are to play in this war, therefore, is to continue their work of investigating agricultural problems and to furnish the resulting information to the farmers for the advancement of their various business enterprises.

Notwithstanding the fact that the stations have grown up through years of unappreciation and in many cases plain neglect, they are quite well prepared for their task of aiding the country in winning the war. They are perhaps better prepared for this emergency than was our army or navy or other branch of government service at the beginning of the war. It is rather significant that the war situation has not necessitated any radical changes in the nature or scope of the existing work at the best of our experimental stations. It has merely lent emphasis to the fundamental nature of this work in general, and to the importance of certain lines of research in particular. The knowledge which the stations have brought forth concerning the production and improvement of crops of every kind, the nature of our soils, crop rotations, the use of commercial and other forms of fertilizer, feeds, and feeding, stock raising, the production of animal products of every kind and allied subjects, is proving most timely to the country just now. Yet the stations are still in their youth.

The war gives promise of bringing them to the state of robust manhood, wherein they may serve our agriculture in a most efficient manner, both during and after the war.

I now wish to call attention to some things which may hamper the stations and make them of little service in winning the war. As it takes men, money and time to make an efficient army, so does it take men, money and time to make an effective station. Some of the stations of the country, possibly the greater part of them, have never, even in times of peace and prosperity, received proper financial support from their respective states. Some stations, particularly those of the South, have never received any state support at all. The psychology of the people of such states is difficult indeed to fathom. It is to be wondered why they maintain teaching and extension agencies, unless through these they hope to develop their state from knowledge picked up on the surface here and there, or that received from the investigations paid for by the Federal Government, and the other states of the Union. The state, which is independent, and which is determined to do its bit, both now and after the war, will render such financial support as may be necessary to its station so that its agricultural development may not be contingent upon the general store of agricultural knowledge alone, but that it may be advanced upon the basis of particular information gained locally within the state, by station investigations.

The other danger confronting station work at this time is the possibility of the conscription of station workers. Our only protection against this possibility is the selective draft. It is to be hoped in this connection that the stations may not be deprived of their more important men and such of their assistants as are necessary and cannot be replaced. The stations, however, must do their duty even in the matter of furnishing men for the army. It is not unfair to the stations for the government to require that they let go any men of draft age who may be replaced by older men or by women workers. In Texas we have lost most of our clerical men and some of our most useful assistants and these have been replaced by competent women without great disadvantage to station work.

To the end that the stations may play well their part in winning the war, let every station man in the country focus his energy

more sharply upon his work than ever before. Though it is hardly possible that in the course of human events he will receive as much honor and glory, or as much self satisfaction from staying with his work as he would in going to the front, it is his plain duty to stay there if the government thinks best. He should be content to continue his labors where he can be of greatest possible service and he should avail himself of his opportunities to give of his means to the cause. He has the opportunity of supporting Red Cross and similar organizations, of investing his savings in Liberty Bonds and, if he does, when the war is over, he may not wear the laurels of an American soldier, but in the last accounting, he will certainly be classed among the immortals of the country who defended it to the extent of their powers in this great war.

A MEMORIAL TO DR. ROBERT HILLS LOUGHRIDGE

"*To the Council of Agriculture:*

"It is recommended that the following statement in memory of our late colleague, Dr. Robert Hills Loughridge, Professor of Agricultural Chemistry, Emeritus, be spread upon the minutes of the Council of Agriculture.

"Early in the morning of Sunday, July 1st, 1917, Robert Hills Loughridge, Ph. D., Professor of Agricultural Chemistry, Emeritus, died at the home of his brother, James A. Loughridge of Waco, Texas.

"Professor Loughridge was born on October 9th, 1843, in Koweta, a Presbyterian Mission Station west of Muscogee, Indian Territory, where his father, the Rev. R. M. Loughridge, D. D., was the first missionary to the Creek Indians in that territory. His mother was Olivia D. Hills, daughter of David Hills, of Rome, New York. Professor Loughridge was prepared for college at his father's mission school and in 1860 entered the La Grange Synodical College in Tennessee. In 1862 that college was disbanded owing to the Civil War and Loughridge enlisted in Company H of the 13th Tennessee Infantry. At the battle of Shiloh he was severely wounded. At the close of the war, he entered the University of Mississippi and there met the man who was to become his teacher and lifelong friend, the late Professor E. W. Hilgard, whom he outlived by only one year and a half.

"In 1871 Loughridge received the bachelor's degree at the University of Mississippi and in 1876 the degree of Ph. D. from the same institution. From 1872 to 1874 he was Adjunct Professor of Chemistry at the institution from which he was graduated and in addition held the post of assistant state geologist of Mississippi. From 1874 to 1878 he was assistant state geologist of Georgia, and from 1878 to 1879 held the position of principal of Sylvania Academy in Georgia. From 1879 to 1882 he was engaged by Professor Hilgard to assist in the preparation of the celebrated report on cotton production in the United States for the Tenth Census. In 1882, he was appointed assistant state geologist of Kentucky, which position he gave up in 1885 to become

Professor of Agricultural Chemistry in the University of South Carolina, where he remained until 1890. In the following year he served again as assistant state geologist of Kentucky, and in 1891 was called by Professor Hilgard to California, where the latter was Professor of Agriculture, Director of the Agricultural Experiment Station and Dean of the College of Agriculture. From that time until 1909, when he retired, Professor Loughridge was engaged in teaching soil physics and soil chemistry, and in investigations on various problems connected with soils in which he and his colleague, Professor Hilgard, were deeply interested. From the time of his retirement until within six weeks of his death he worked, as his health permitted, on the preparation for publication of a large amount of data collected by himself, Professor Hilgard, and other members of the division of Soil Chemistry and Bacteriology of the Department of Agriculture. That task he never completed.

"Professor Loughridge was married in New Orleans on October 19, 1886, to Miss Bessie May Webb, who died on January 23, 1895, at their home in Berkeley. There were no children.

"Specifically, some of the studies which engaged Dr. Loughridge's attention were the following: Chemical and mechanical analyses of typical arid soils of California, studies on the nature, movements and effects of alkali salts in soils, and investigations on moisture movements under systems of irrigation. In all his work, he had become accustomed from his youth to seek the advice and assistance of his colleague, Professor Hilgard, whose problems became his. The long and remarkable devotion which Professor Loughridge evinced for his teacher and friend is an instance of a rare attachment of man to man, which in our workaday world is ever a source of wonder. Whole-heartedly and deeply devoted to his masterful and distinguished colleague and friend, he was content to labor humbly at his task in furtherance of the researches which Hilgard planned, elaborated and rendered celebrated.

"A modest, gentle and devoted character, generous to a fault, and always a gentleman was our late colleague, Robert Hills Loughridge. He had learned to regard the "world and his neighbor" with a smile and to take his part unostentatiously in its ever changing drama. Requiescat in pace."

MEMBERSHIP OF THE SOCIETY

Honorary Member

1899—Hon. James Wilson, LL. D., *Traer, Iowa.*

Regular Members

(Arranged alphabetically.)

The prefixed date is the year of election.

1907—Edwin West Allen, B. S. (Mass. Agri. Coll. and Boston Univ., '85), Ph. D. (Gottingen, '90); *U. S. Dept. Agri., Washington, D. C.;* Asst. Chem. Mass. Expt. Sta., '85–'88; Asst. Office Ext. Stas., '90–'93; Asst. Dir., do., '93—; Ed. Expt. Sta. Record, '95—.

1913—Harry Orson Allison, B. S. (Univ. Ill., '06), M. S. (do., '06); *Columbia, Mo.;* Instr. and Asst. in Anim. Husb., Univ. Ill., and Expt. Sta., '06–'10; Asst. Prof. Anim. Husb., Univ. Mo., '10–'12; Assoc. Prof., do., and Anim. Husb. Mo. Expt. Sta., '12—.

1913—John W. Ames, B. S. (Case School Appl. Sci., '98), M. S. (do., '06); *Wooster, Ohio;* Chem., Ohio Expt. Sta., '99—.

1889—Henry Prentiss Armsby, B. S. (Worcester Poly. Inst., '71), Ph. B. (Sheffield Sci. School, '74), Ph. D. (Yale Univ., '79), LL. D. (Univ. Wis., '04); *State College, Pa.;* Chem. Conn. Expt. Sta., '77–'81; Vice Prin. Storr Agr. School, '81–'83; Prof. Agr. Chem., Univ. Wis., '83–'87; Dir. Pa. Expt. Sta., '87–'07; Dean School of Agri., Penn. State College. '95–02; Dir. Inst. Animal Nutrition, '07—.

1886—Joseph Charles Arthur, B. S. (Iowa State Coll., '72), M. S. (do., '77), D. Sc. (Cornell Univ., '86); *Lafayette, Ind.;* Instr. Biol., Iowa State Coll., '76–'78; Instr. Bot., Univ. Wis., '79–'81; do., Univ. Minn., '82; Bot. N. Y. Expt. Sta., '84–'87; Prof. Bot., Purdue Univ., '87–'88; Prof. Veg. Phys. and Path., do., and Bot., Ind. Expt. Sta., '88–'15; Prof. Emeritus Bot., Purdue Univ., '15.

1906—Liberty Hyde Bailey, B. S. (Mich. Agr. Coll., '82), M. S. (do., '85), LL. D. (Univ. Wis., '07); *Ithaca, N. Y.;* Prof. Hort. and Landscape Gardening, Mich. Agr. Coll., '84–'88; Prof. Hort., Cornell Univ., '88–'03; Dir. Coll. Agr. and Expt. Sta., Cornell Univ., '03–'13; Editor and Writer, '13—.

1914—Elmer Darwin Ball, B. S. (Iowa St. Coll., '95); M. S. (do., '98), Ph. D. (Ohio State Univ., '07); *Logan, Utah;* Asst. in Zool. and Ent., Iowa St. Coll., '95–'97; Asst. in Zool. and Ento., Colo. Agr. Coll., '97–'02; Prof. Zool. and Ento., Utah Agr. Coll., '02–'07; Dean School Agr. and Dir. Expt. Sta., Utah Agr. Coll., '07—.

1879—William James Beal, A. B. (Univ. Mich., '59), A. M. (do., '63), Sc. B. (Harvard Univ., '65), Sc. M. (Univ. Chicago, '75), Ph. D. (Univ. Mich., '80), D. Sc. (Mich. Agr. Coll., '05); *Amherst, Mass.;* Prof. Bot. Mich. Agr. Coll., '70–'72; Prof. Bot. and Hort., '72–'81; Prof. Bot. and Forestry, '81–'03; Prof. Bot., '03–'10; Prof. Emeritus, '10—.

1916—Orville Andrew Beath, B. A. (Univ. Wis., '08); M. S. (do., '12), Instr. H. S. Science; Instr. Chem., Univ. of Kans., '12–'14; Asst. Chem., U. S. Forest Products Lab., '14; Research Chem., Univ. Wyo., '14—.

1912—Augustine Wilberforce Blair, B. S. (Haverford, '92), A. M. (do., '96); *New Brunswick, N. J.;* Prof. Chem., Guilford Coll., '96–'97; Asst. Chem., N. C. Expt. Sta., '97–'98; State Chem., N. C., '98–'99; Asst. Chem., Fla. Expt. Sta. and Univ., Fla., '99–'06; Chem. Fla. Expt. Sta., '06–'12; Assoc. Soil Chem., N. J. Expt. Sta., '12—.

1913—Maurice Adin Blake, B. S. (Mass. Agr. Coll., '04; *New Brunswick, N. J.;* Asst. Hort., R. I. Agr. Coll. and Expt. Sta., '04–'05; Instr. Hort., Mass. Agr. Coll., '05–'06; Hort., N. J. Expt. Sta., '06—.

1893—Henry Luke Bolley, B. S. (Purdue Univ., '88), M. S. (do., '89); *Agricultural College, N. Dak.;* Instr. Biol. and Asst. Bot. to Expt. Sta., Purdue Univ., '90; Prof. Bot. and Plant Path., N. Dak. Agr. Coll. and Bot. and Plant Path. of Expt. Sta., do., '90—.

1909—William Penn Brooks, B. Sc. (Mass. Agr. Coll., '75), Ph. D. (Halle, '97); *Amherst, Mass.;* Prof. Agr. Imp. Coll. Agr., Sapporo, Japan, '77–'88; Prof. Bot., do., '81–'88; Pres., do., *ad interim* '80–'83 and '86–'87; Prof. Agr. and Agr., Mass. Agr. Coll. and Expt. Sta., '89–'09; acting Pres. and Dir., do., '05–'06; Dir. Expt. Sta., '06—.

1901—Edgar Allen Burnett, B. S. (Mich. Agr. Coll., '87); D. Sc. (do., '17); *Lincoln, Nebr.;* Asst. Mich. Agr. Coll., '89–'93; Prof. Anim. Husb., S. Dak. Agr. Coll., '96–'99; Prof. Anim. Husb., Univ. Nebr., '99–'07; Dir. Nebr. Expt. Sta., '01;— Dean Coll. Agr., '09—.

1908—Kenyon L. Butterfield, B. S., (Mich. Agr. Coll., '91), A. M. (Univ. Mich., '02); *Amherst, Mass.;* Supt. Mich. Farmers' Institutes, '95–'99; Instr. Univ. Mich., '02; Pres. Rhode Island Coll., '03–'06; Pres. Mass. Agr. Coll. and Head Div. Rural Sociol., '06—.

1909—Frank Kenneth Cameron, A. B. (Johns Hopkins, '91), Ph. D. (do., '94); *Washington, D. C.;* Fellow Cornell, '94–'95; Assoc. Prof., Catholic Univ., '95–'97; Asst. Physical Chem., Cornell, '97–'98; Expert, U. S. D. A., '98–'99; Soil Chemist, do., '99—.

1914—Ira Detrick Cardiff, B. S. (Knox Coll., '99); Grad. Stud. Univ. of Chicago, '02–'04; Ph. D. (Columbia Univ., '06); *Pullman, Wash.,* Asst. in Bot., Columbia Univ:, '04–'06; Asst. Prof. of Bot., Univ. of Utah, '06–'07; Prof. of Bot., do., '07–'08; do. Washburn Coll., '08–'12; do. Univ. of Kans., '12; Prof. of Plant Physiol. and Bact., State Coll. of Wash., 1913; Dir., State Expt. Sta., State Coll. of Wash., '13—.

1908—Mark Alfred Carleton, B. S. (Kans. Agr. Coll., '87), M. S. (do., '93); *Washington, D. C.;* Ass't. Bot., Kans. Expt. Sta., '92–'93; Cerealist, Bur. Plant Indus., U. S. D. A., '94–'12; Gen. Mgr., Penn. Chestnut Tree Blight Com., '12–'13; Cerealist, Bur. Plant Indus., U. S. D. A., '13—.

1915—William L. Carlyle, B. S. (Ontario Agr. Coll., '92), M. S. (Colo. Coll., '05); *Stillwater, Okla.*, in chg. Dairy School, Ontario, '93; Lect. Dairy and Live Stock, Minn. Farm Insts., '93–'97; Prof. Anim. Husb., Univ. of Wis., '97–'03; Prof. of Agr., Colo. Coll. and Dean Coll. of Agr., '04–'08; Genl. Secy. A. J. Knollin Co., Denver, Colo., '08–'10; Dir. Idaho Expt. Sta., '10–'14; Dir. Okla Expt. Sta., '14—.

1905—Louis George Carpenter, B. S. (Mich. Agr. Coll., '79), M. S. (do., '84), Asst. Prof., Mich. Agr. Coll., '85–'88; Irr. Eng., Col. Agr. Coll. and Exp. Sta., '88–'10; Dir. Expt. Sta., do., '99–'10; State Eng., '03–'05; Consulting Irrigation Engineer, Denver, Colo., '10—.

1901—Louis Adelbert Clinton, B. S. (Mich. Agr. Coll., '89), M. S. (do., '97); *U. S. Dept. Agr., Washington, D. C.;* Asst. to Dir. Mich. Expt. Sta., '89–'93; Asst. Prof. Agr., Clemson Coll., '93–'95; Asst. Agr., Cornell Expt. Sta., '95–'02; Dir. Storris Expt. Sta. and Prof. Agr., Conn. Agr. Coll., '02–'12; Agriculturist, Bur. Plant Indus., '12–'15; Asst. Chief, Office of Extension Work, North and West, U. S. D. A., '15—.

1910—John Waldo Connaway, D. V. S. (Chicago Vet. Coll., '90), M. D. (Univ. Mo., '91); *Columbia, Mo.;* Prof. Physiology, Univ. Mo., '91–'97; Vet. Expt. Sta., do., '97–'00; Prof. Compar. Med. and Vet. to Expt. Sta., Univ. Mo., '00—.

1915—Thomas Cooper, B. S. of A. (Minn. Coll. of Agri., '08); *Fargo, N. Dak.;* Spec. Agt. Bureau of Statistics '04–'10; Statistical Agt. and Asst., Minn. Expt. Sta., '04–'08; Asst. Agriculturist, Univ. of Minn., '08–'10; Asst. Agriculturist in Chg. Farm Mgmt., '10–'11; Dir. Better Farming Assn. of N. Dak.; '11–'14; Dir. Agrl. Expt. Sta. and Dir. Agrl. Ext., N. Dak. Agrl. Coll., '14—.

1910—Lee Cleveland Corbett, B. S. (Cornell Univ., '90), M. S. (do., '96); *Washington. D. C.;* Asst. Hort., Cornell Univ., '91–'93; Prof. Hort. and Forestry, S. Dak. Coll., '93–'95; do., Univ. W. Va. and Expt. Sta., '95–'01; Hort., U. S. Dept. Agr., '01–'13; Asst. Chief Bur. Plant Indus., do., '13–'14; Hort., do., 14—.

1914—Arthur Burton Cordley, B. S. (Mich. Agr. Coll., '88), M. S. (do., '01); *Corvallis, Ore.;* Grad. Student, Cornell Univ., '00–'07; Asst., in Ento., Mich. Agr. Coll., '88–'90; Asst. Ento. Vt. Expt. Sta., '90–'91; Asst. Ento., U. S. D. A., '91–'93; Prof. Zool. and Ento. Expt. Sta., Ore. Agr. Coll. '95–'12; Dean, School of Agr., do., '07—; Dir. of Expt. Sta., do., '14—.

1902—Charles Francis Curtiss, B. S. A. (Iowa State Coll., '87), M. S. A. (do., '93), D. Sc. (Mich. Agr. Coll., '07; *Ames, Iowa;* Asst. Dir. Iowa Expt. Sta., '91–'97; Prof. Agr. and Acting Dir., Iowa Expt. Sta., '97–'00; Prof. Agr. and Dir., do., '00–'02; Dean and Dir., '02—.

1911—William Haddock Dalrymple, M. R. C. V. S. England, '86; *Baton Rouge, La.;* Prof. Vet. Sci., La. State Univ., '89—; Vet., La. Expt. Sta., '89—.

1906—Eugene Davenport, B. S. (Mich. Agr. Coll., '78), M. S. (do., '81), M. Agr. (do., '95), LL. D. (do., '07); *Urbana, Ill.;* Prof. Agr., Mich. Agr. Coll., '89–'90; Dir. Coll. of Agr. Piracicaba, Brazil, '91–'92; Dean Coll. of Agr., Univ., Ill., '95—; Dir. Agr. Expt. Sta.. '96—; Dir. Agr. Ext., '14—.

1913—Robert John H. DeLoach, A. B. (Univ. Ga., '98), A. M. (do., '06); *Experiment, Ga.;* Bot., Ga. Expt. Sta., '06–'08; Prof. Cotton Indus., Univ. Ga., '08–'13; Dir., Ga. Expt. Sta., '13—.

1911—William Rufus Dodson, B. S. (Univ. Mo., '90), A. B. (Harvard Univ., '94); *Baton Rouge, La.;* Asst. Biol., Univ. Mo., '90–'93; Prof. Bot., La. Univ., '94–'02; Asst. Dir., La. Expt. Stas., '02–'05; Dir., do., '05—; Dean, Coll. Agr., La. Univ., '09—.

1910—John Frederick Duggar, B. S. (Miss. Agr. Coll., '87), M. S. (do., '88); *Auburn, Ala.;* Asst. in Agr., Tex. Agr. Coll., '87–'89; Asst. Dir., S. C. Expt. Sta., '90–'92; Agr. Editor Office Expt. Stas., U. S. D. A., '93–'95; Prof. Agr., Ala. Poly. Inst., '96—; Dir. Ala. Expt. Sta., '03—.

1913—Clarence Henry Eckles, B. S. A. (Iowa State Coll., '95), M. S. (do., '97); *Columbia, Mo.;* Instr. and Asst. in Dairying, Iowa Coll. and Expt. Sta., '96–'01; Asst. Prof. Dairy Husb. Univ. Mo., and Dairyman, Mo. Expt. Sta., '01–'06; Prof. and Dairyman, do., '06—.

1899—David Grandison Fairchild, B. S. (Kans. State Coll., '88), M. S. (do., '93); *Washington, D. C.;* Naples Zool. Sta., '93; Breslau and Berlin, '94; Bonn, '95; Buitenzorg Botanic Gardens, '96; Asst. Path. U. S. Dept. Agr., '89–'92; Special Agt. in Charge Seed and Plant Production, '97–'98; Agr. Explorer, '98–'03; in charge Foreign Seed and Plant Introduction, U. S. Dept. Agr., '03—.

1880—William Gibson Farlow, A. B. (Harvard Univ., '66), M. D. (do., '70), LL. D. (do., '96; Univ. Glasgow, '01; Univ. Wis., '04); *24 Quincy St., Cambridge, Mass.;* Asst. Prof. Bot., Harvard Univ., '74–'79; Prof. Cryptg. Bot., do., '79—.

1890—Bernhard Edward Fernow (Munden Forest Acad. Grad., '73), LL. D. (Univ. Wis., '97; Queen's, '03); *Toronto, Can.;* Chief, Div. Forestry, U. S. Dept. Agr., '86–'98; Dir. N. Y. State Coll. of Forestry, '98–'03; Lecturer Yale Forestry School, '04; Prof. of Forestry, Univ. of Toronto, '07—.

1911—Martin Luther Fisher, B. S. (Purdue Univ., '03), M. S. (Univ. Wis., '11); *Lafayette, Ind.;* Asst. in Agr., Purdue Univ., '03–'04; Instr. Agr., do., '04–'06; Asst. Prof. Agron., do., '06–'08; Assoc. Prof. Agron., do., '08–'10; Prof. Crop Prod., do., '10—; Asst. Agr., Indiana Expt. Sta., '03–'10; Assoc. in Crops, do., '10—.

1910—Eenest Browning Forbes, B. Sc. (Univ. Ill.. '97), B. S. Agr. (do., '02), Ph. D. (Univ. Mo., '08); *Wooster, Ohio;* Zool. Asst., Ill. Biol. Sta., '94–'96; Asst. to State Ento. of Minn., '97–'98; Acting State

Ento. Minn., '01; Asst. in Anim. Husb., Ill. Expt. Sta., '01–'02; Instr. Anim. Husb., Univ. Ill., '02–'03; Asst. Prof. Anim. Husb., Univ. Mo., '03–'07; Chief in Nutr., Ohio Expt. Sta., '07—.

1908—STEPHEN ALFRED FORBES, Ph. D. (Ind. Univ., '84), LL. D. (Univ. Ill., '05), *Urbana, Ill.;* Prof. Zool., Univ. Ill., '84–'09; State Ento. Ill., '82—; Dir. Ill. State Lab. of Nat. Hist.,' 77—; Dean Coll. of Sci., Univ. of Ill., '88—.

1916—JULIUS HERMAN FRANDSEN, B. S. A. (Iowa State Agr. Coll., '02), M. S. (do., '04), Asst., Chem. Iowa Expt. Sta., '04–'06; Com'l Dairy Work, Portland, Or., '06–'09; Prof. Dairy Husb., Moscow, Ida., '09–'11; Prof. Dairy Husb., Univ. of Nebr., Lincoln, Nebr., '11—.

1911—GEORGE STRONACH FRAPS, B. S. (N. C. Agr. Coll., '96), Ph. D. (Johns Hopkins Univ., '99); *College Station, Tex.;* Asst. Prof. Chem., N. C. Agr. Coll., and Asst. Chem. in Expt. Sta., '99–'03; Asst. Chem., Tex. Expt. Sta., '03–'04; Assoc. Chem., do., '04–'05; Chem., do., '05—; Assoc. Prof. Chem., Tex. Agr. Coll., '03–'05; Acting Prof., do., '05–'06; Assoc. Prof. Agr. Chem., do., '06—; State Chem., '06.

1888—WILLIAM FREAR, A. B. (Bucknell Univ., '81), Ph. D. (Ill. Wesleyan Univ., '83); *State College, Pa.;* Asst. Sci., Bucknell Univ., '81–'83; Asst. Chem., U. S. Dept. Agr., '83–'85; Prof. Agr. Chem., Pa. State Coll., '85—; Vice Dir. and Chem., Pa. Expt. Sta., '87—.

1913—JONS AUGUST FRIES, B. S. (Pa. State Coll., '99), M. S. (do., '06); *State College, Pa.;* Asst. Chem., Pa. Expt. Sta., '89–'98; Expert Asst. Anim. Nutr., do., '98–'08; Asst. Dir. Inst. Anim., Nutr., '08—.

1908—BEVERLY THOMAS GALLOWAY, B. S. (Univ. Mo., '84), LL. D. (do., '02); *Ithaca, N. Y.;* Asst. Hort., Univ. Mo., '84–'87; Asst. Path., U. S. Dept. Agr., '87–'88; Path. and Chief, Div. Veg. Path and Physiol., do., '88–'01; Chief Bur. Plant Indus., do., '01–'13; Asst. Sec. of Agr., '13–'14; Dean N. Y. State Coll. of Agr. at Cornell Univ.; Dir. Cornell Univ. Agr. Expt. Sta. and Agr. Ext., '14—.

1894—HARRISON GARMAN, D. Sc. (St. Univ. of Kentucky); *Lexington, Ky.;* First Asst. State Lab. Nat. Hist., Ill., '83–'89; Asst. Prof. Zool., Univ. Ill., '85–'89; Ento. and Bot., Ky. Expt. Sta., '89—; State Ento., Ky., '97—; Prof. of Ento. and Zool., St. Univ. of Kentucky, '11—.

1894—CHARLES CHRISTIAN GEORGESON, B. S. (Mich. Agr. Coll., '78), M. S. (do., '82); *Sitka, Alaska;* Asst. Ed. of *Rural New Yorker*, '78–'80; Prof. Agr. and Hort., Tex. Agr. Coll., '80–'83; Prof. Agr. Coll. of Agr., Imperial Univ., Tokyo. Japan, '86–'89; Prof. Agr., Kans. State Agr. Coll., '90–'97; Special Agt. U. S. Dept. Agr., Dairy Industry, Denmark, '93; Asst. Agrostologist, U. S. Dept. Agr., '97–'98; Special Agt. in charge Alaska Expt. Sta., do., '98—.

1893—CLARENCE PRESTON GILLETTE, B. S. (Mich. Agr. Coll., '84), M. S. (do., '88); D. Sc. (do., '17); *Fort Collins, Colo.;* Asst. Zool., Mich. Agr. Coll., '87–'88; Ento. Iowa Expt. Sta., '88–'91; Prof. Zool. and Ento., Colo. Agr. Coll. and Ento. Expt. Sta., do., '91—; Dir. Expt. Sta., do., '10—; Colo. State Ento., —.

1911—Arthur Goss, B. S. (Purdue Univ., '88), M. S. (do., '95); *Lafayette, Ind.;* Asst. Chem., Ind. Expt. Sta., '88–'92; Asst., Ind. Weather Serv., '89–'92; Prof. Chem., N. Mex. Agr. Coll. and Chem. in Expt. Sta., '92–'03; Vice-Dir., N. Mex. Expt. Sta., '95–'00; Dir. Ind. Expt. Sta., '03—.

1916—Howard John Gramlich, B. S. (Univ. of Nebr., '11); Vice-Dir. Extension Work Nebr., '11–'13; Prof. Animal Husb., do., '13—.

1909—Harry Sands Grindley, B. S. (Univ. Ill., '88) Sc. D. (Harvard, '94); *Urbana, Ill.;* Asst. Chem., Univ. Ill., '88–'92; Asst. Chem., Harvard, '92–'93; Fellow Harvard, '93–'94; Instr. Chem., Univ. Ill., '94–'95; Asst. Prof. Chem., do., '95–'99; Assoc. Prof. Chem., do., '99–'04; Prof. and Dir. Chem. Lab., do., '04–'07; Prof. An. Chem., do., and Chief An. Chem., Expt. St., '07—.

1909—Theophilus L. Haecker, *University Farm, St. Paul, Minn.;* in charge Dairy Husb., Minn. Univ. and Expt. Sta., '92–'07; Prof. Dairy Husb. and Anim. Nutrition, do., '07–'09; Prof. Dairying, Anim. Husb. and Animal Nutrition, do., '10—.

1880—Byron David Halsted, B. S. (Mich. Agr. Coll., '71), M. S. (do., '74), Sc. D. (Harvard Univ., '78); *New Brunswick, N. J.;* Ed. *American Agriculturist*, '79–'85; Prof. Bot. Iowa State Coll., '85–'89; Prof. Bot. and Hort., Rutgers Coll., '89–'10; Bot., N. J. Expt. Sta., '89—.

1902—Niels Ebbensen Hansen, B. S. (Iowa State Coll., '87), M. S. (do., '95); *Brookings, S. Dak.;* Asst. Prof. Hort, Iowa State Coll., '91–'95; Prof. Hort. and Forestry, S. Dak., Agr. Coll., and Hort., Expt. Sta., '95—.

1910—Joseph Nelson Harper, B. S. (Miss. Agr. Coll., '95), M. A. (Ky. Agr. Coll., '06); *Clemson College, S. C.;* Dairy Husb.. Miss. Expt. Sta., '95; Dairy Husb., Ky. Expt. Sta., '96–'98; Agriculturist, do., '98–'05; Dir. and Agron., S. C. Expt. Sta., '06—.

1910—Burt Laws Hartwell, B. S. (Mass. Agr. Coll. and Boston Univ.. '89), M. S. (Mass. Agr. Coll., '00), Ph. D. (Univ. Pa., '03); *Kingston, R. I.;* Asst. Chem. Mass. Expt. Sta., '89–'91; Asst. Chem., R. I. Expt. Sta., '91–'03; Assoc. Chem., do., '03–'07; Chem., do., '07—; Prof. Agr. Chem., R. I. State Coll., '08—; Dir.. R. I. Expt. Sta.,'12— Agron., R. I. Expt. Sta., '13—.

1905—Willet Martin Hays, B. Agr. (Iowa State Coll., '85), M. Agr. (do., '86); *Kennett Sq., Pa.;* Asst. Iowa Agr. Coll., '86; Assoc. Ed.. *Prairie Farmer*, '87; Asst. in Agr., Iowa Agr. Coll., '88–'89; Prof. Agr. and Agrlst., Minn. Agr. Coll. and Expt. Sta., '90–'91; do., N. Dak. Agr. Coll. and Expt. Sta., '92–'93; do., Minn. Agr. Coll. and Expt. Sta., '93–'04; Asst. Sec. of Agr., U. S. Dept. Agr., '04–'13; Farmer, 15—.

1911—Harry Hayward, B. S. (Cornell Univ., '94), M. S. (do., '01; *Newark, Del.*, Asst. Prof. Dairy Husb., Pa. State Coll., '97–'02; Assoc. Prof. Anim. and Dairy Husb., N. H. Agr. Coll., '02–'03; Asst. Chief Dairy Div., U. S. Dept. Agr., '03; Dir. Agr. Dept., Mount Hermon School, '03–'06; Dean Agr. Dept., Del. Coll., and Dir. Del. Expt. Sta., '06;— Dir. Agrl. Ext., '14—.

1909—WILLIAM PARKER HEADDEN, A. B. (Dickinson. '72), A. M. (do., '75), Ph. D. (Univ. Giessen, '74); *Fort Collins, Colo.;* Asst., Univ. Pa., '74–'76; Prof. Chem., Md. Agr. Coll.. '80–'84; do., Univ. Denver, '84–'89; do., S. Dak. School of Mines, '89–'91; Dean, do., '92–'93; Prof. Chem. and Geol., Colo. Agr. Coll., and Chem., Expt. Sta., '93—.

1909—ULYSSES PRENTISS HEDRICK, B. S. (Mich. Agr. Coll., '93) M. S. (do., '95); *Geneva, N. Y.;* Asst. Hort., Mich. Agr. Coll., '93–'95; Prof. Bot. and Hort., Ore. Agr. Coll., and Hort., Expt. Sta., '95–'97; Prof. Bot. and Hort., and Hort., Expt. Sta., Utah, '97–'99; Prof. Hort., Mich. Agr. Coll., '99–'05; Hort., N. Y. Expt. Sta., '05—.

1905—JOSEPH LAWRENCE HILLS, B. S. (Mass. Agr. Coll. and Boston Univ., '81), D. Sc. (honorary, '03, Rutgers Coll.); *Burlington, Vt.;* Asst. Chem., Mass. Expt. Sta., '82–'83; Asst. Chem., N. J. Expt. Sta., '84–'85; Chem. Phos. Mining Co., Ltd., Beaufort, S. C., '85–'88; Chem., Vt. Expt. Sta., '88–'98; Dir., do., '98—; Prof. Agr. Chem., Univ. Vt., '93—; Dean, Dept. Agr., do., '98—.

1889—LELAND OSSIAN HOWARD, B. S. (Cornell Univ., '77), M. S. (do., '86), Ph. D. (Georgetown Univ., '96); *Washington, D. C.;* Asst. Ento., U. S. Dept. Agr., '78–'94; Chief Ento., do., '94—; Perm. Sec., A. A. A. S., '98—.

1912—WALTER LAFAYETTE HOWARD, B. Agr., B. S. (Univ. Mo., '01), M. S. (do. '03) Ph. D. (Univ. Halle-Wittenberg, '06); *University Farm, Davis, Calif.;* Assist. in Hort., Univ. Mo.; '01–'03; Instr., do. '03–'04; Asst. Prof., do., '05–'08; Sec., Mo. State Board Hort., '08–'12; Prof. Hort., Univ. Mo., '08–'15; Assoc. Prof. Pomology, Univ. of Calif., '15—.

1903—THOMAS FORSYTH HUNT, B. S. (Univ. Ill., '84), M. S. (do., '92), D. Agr. (do., '04), D. Sc. (Mich. Agr. Coll., '07); *Berkeley, Cal.;* Asst. State Ento. of Ill., '85–'87; Asst. Agr., Univ. of Ill., '86–'88; Asst. Agr. Ill. Expt. Sta., '88–'91; Prof. Agr., Pa. State Coll., '91–'92; Prof. Agr., Ohio State Univ., '92–'95; Dean Coll. Agr., Ohio State Univ., '95–'03; Prof. Agron., Cornell Univ., and Agron., Expt. Sta., '03–'06; Dean Coll. Agr. and Dir. Agr. Expt. Sta., Pa. State Coll., '06–'12; Dean Coll. Agr., Univ. Cal., and Dir. Expt. Sta., '12—.

1908—WILLIAM DANIEL HURD, B. S. (Mich. Agr. Coll., '99), M. Agr. (do., '08); *Amherst, Mass.;* Instr., Lansing High School, '99–'01; Prof. Hort., Briarcliff Agr. School, '01–'03; Prof. Agri., Univ. Me., '03–'05; Acting Dean, Coll. of Agr., do., '05–'06; Dean, '06–'09; Dir. Ext. Service, Mass. Agr. Coll., '09–'17; Ass't Sec'y Agr., Wash., D. C., '17—.

1898—HENRY CLAY IRISH, B. S. (S. Dak. Agr. Coll., '91), M. S. (Iowa State Coll., '98); *Missouri Botanical Garden, St. Louis, Mo.;* Hort. Asst., Mo. Bot. Gard., '95–'02; Supt., do., '03–'12; Landscape Architect, '12–'13; Asst. Prof., Landscape Gard. and Flor., Iowa St. Coll., '13–'14; Supervisor, School Gardens, St. Louis, '14—.

1908—MEYER, EDWARD JAFFA, Ph. B. (Univ. Cal., '77), M. S. (do., '96); *Berkeley, Cal.;* Asst. Chem., U. S. Census, '79–'80; Asst. Agr., Dept., Univ. Cal., '80–'81; Asst. Chem., Northern Transcontinental Surv., '81–'83; Asst. Chem., Univ. Cal., '83–'96; Asst. Prof. Agr., do., '96–'06; do., Nutr., '06–'08; Prof. Natr., do., '08—.

1885—EDWARD HOPKINS JENKINS, A. B. (Yale Univ.. '72), Ph. D. (do., '79); *New Haven, Conn.;* Chem., Conn. Expt. Sta., '76–'00; Vice-Dir., do., '82–'00; Dir., do., '00—; Treas., do., '01—; Dir. Storrs Expt. Sta., '12—.

1915—J. SHIRLEY JONES, B. S. (Univ. of Calif., '03); M. S. (Cornell Univ., '14); *Moscow, Idaho;* Asst. in Chem., Univ. of Calif., '02–03; Asst. Chem. to Dr. H. E. Miller, San Francisco, '03–'04; Chem. for Giant Powder Co., San Jose, Calif., '05–'07; Chem. Idaho Expt. Sta. and Prof. Agr. Chem., Idaho St. Coll. of Agr., '07–'14; Dir. Idaho Expt. Sta., '14—.

1894—WHITMAN HOWARD JORDAN, B. S. (Univ. Me., '75), M. S. (do., '79), D. Sc. (do., '96), LL. D. (Mich. Agr. Coll., '07); *Geneva, N. Y.;* Asst. Chem., Conn. Expt. Sta., '78–'79; Instr. Agr., Univ. Me., '79–'80; Prof. Agr. and Agr. Chem., Pa. State Coll., '81–'85; Dir. Me. Expt. Sta., '85–'96; Prof. Agr., Univ. Me., '94–'96; Dir., N. Y. Expt. Sta., '96—.

1912—JOHN CHESTER KENDALL, B. S. (N. H. Coll., '02); *Durham, N. H.;* Instr. in Dairy Husb., N. C. Agr. Coll., '02–'03; Asst. Prof. of Dairy Husb., do., '03–'06; State Dairy Comr., Kans., '06–'07; Prof. of Dairy Husb., Kans. Agr. Coll., '08–'10; Dir., N. H. Expt. Sta., '10—; Dir. Agr. Ext., '11—.

1916—ALVIN KEZER, B. Sc. (Univ. of Nebr., '04), M. A. (do., '06); Special Agent B. P. I., '04–'06; Assoc. and Prof. of Soils, Univ. of Nebr., '06–'09; Prof. of Agronomy and Farm Manager, Colo. Agr. Coll., '09—.

1909—BENJAMIN WESLEY KILCORE, B. S. (Miss. Agr. Coll., '88), M. S. (do., '90); *Raleigh, N. C.;* Asst. Chem., Miss. Agr. Coll., '88–'89; do., N. C. Expt. Sta., '89–'97; Prof. Chem., Miss. Agr. Coll. and Agr. Expt. Sta., '97–'99; State Chem., N. C., '99—; Dir., N. C. Expt. Sta., '01–'07; do., '13—.

1911—HENRY GRANGER KNIGHT, A. B. (Univ. Wash., Seattle, '02), A. M. (do., '04); *Laramie, Wyo.;* Asst. Chem., Univ. Wash., '00–'01; Instr., do., '01–'02; Asst. Chem., Univ. Chicago, '02–'03; Asst. Prof. Chem., Univ. Wash., '03–'04; Prof. Chem., Univ. Wyo., and State Chem., '04—; Dir., Wyo. Expt. Sta., '10—.

1916—E. J. KRAUS, B. S. (Mich. Agr. Coll., '07); Ph. D. (Univ. of Chicago '17); U. S. D. A. Bur. Ent., '07–'09; Ore. Agr. Expt. Sta., Prof. Research in Hort., '09—.

1889—EDIN FREMONT LADD, B. Sc. (Univ. Me., '84); *Agricultural College, N. Dak.;* Asst. Chem., N. Y. State Expt. Sta., '84–'87; Chief Chem., do., '87–'90; Prof. Chem., N. Dak. Agr. Coll. and Chem. Expt. Sta., '90—; Food Comr. and State Chem., N. Dak., '00—.

1899—Joseph Bridgeo Lindsey, B. Sc. (Mass. Agr. Coll., '83), Ph. D. (Univ. Gottingen, '92); *Amherst, Mass.;* Asst. Chem., Mass. State Expt. Sta., '83–'85; Commercial Chem., '85–'89; Assoc. Chem., Mass. State Expt. Sta., '92–'95; Head Dept. Foods and Feeding, Hatch Expt. Sta., '95–'07; Chem., Mass. Expt. Sta., '07—; Vice Dir., do., '09—; Head Dept. Chem., Mass. Agr. Coll. and Goessmann Prof. of Agr. Chem., '11—.

1911—Frederick Bloomfield Linfield, B. S. A. (Ontario Agr. Coll., '91); *Bozeman, Mont.;* Asst. in Dairying, Ontario Agr. Coll., '92–'93; Prof. Anim. Indus. and Dairying, Utah Agr. Coll., '93–'02; Prof. Agr., Mont. Agr. Coll., '02—; Acting Dir., Mont. Expt. Sta., '03; Dir., do., '04—.

1912—Charles Bernard Lipman, B. Sc. (Rutgers Coll., '04), M. Sc. (do., '09), M. S. (Univ. Wis., '09), Ph. D. (Univ. Cal., '10); *Berkeley, Cal.;* Instr. in Soil Bact., Univ. Cal., '09–'10; Asst. Prof. Soils, do., '10–'12; Assoc. Prof. of Soils, do., and Soil Chem. and Bact., Cal. Expt. Sta., '12–'13; Prof. of Soil Chem. and Bact. do., '13—.

1909—Jacob G. Lipman, B. Sc. (Rutgers, '98), A. M. (Cornell, '00), Ph. D. (do., '03); *New Brunswick, N. J.;* Asst. Chem., N. J. Expt. Sta., '98–'99; Fellow Chem., Cornell, '01; Soil Chem. and Bact., N. J. Expt. Sta., '01—; Asst. Prof. Agr., Rutgers, '06–'07; Assoc. do., '07–'10; Prof. Soil Chem. and Bact., '10—; Dir. N. J. Expt. Stas., '11—.

1911—Charles Alfred Lory, B. Ped. (State Normal School, Greeley, Colo., '98), B. S. (Univ. Colo., '01), M. S. (do., '02), LL. D. (do., '09); *Fort Collins, Colo.;* Asst. in Physics, Univ. Colo., '99–'02; Prin. Cripple Creek High School, '02–'04; Acting Prof. Physics, Univ. Colo., '04–'05; Prof. Physics and Elect. Engin., Colo. Agr. Coll., '07–'09; Pres., do., '09—.

1911—Arthur Gillett McCall, B. S., Agr. (Ohio State Univ., '00); *Columbus, Ohio;* Asst., Bur. Soils, U. S. Dept. Agr., '00–'04; Asst. Prof. Agron., Ohio State Univ., '04–'05; Assoc. Prof. Agron, do., '05–'06; Prof. Agron., do., '06; now Md—.

1911—Charles Edward Marshall, Ph. B. (Univ. Mich., '95), Ph. D. (do., '02); *Amherst, Mass.;* Asst. Bact., Univ. Mich., '93–'96; do., Mich. Expt. Sta., '96–'98; Bact. and Hygienist, do., '98–'12; Sci. and Vice Dir., do., '08–'12; Prof. Bact. and Hyg., Mich. Agr. Coll., '03–'12; Dir. Graduate School and Prof. of Microbiol., Mass. Agr. Coll., '12—.

1911—Frederick Rupert Marshall, B. S. Agr. (Ontario Agr. Coll., '99). B. S. A. (Iowa State Coll., '00); *Washington, D. C.;* Asst. Prof. Anim. Husb., Iowa State Coll., '01–'03; Prof. Anim. Husb., Tex. Agr. Coll., '03–'07; Prof. Anim. Husb., Ohio State Univ., '07–'12; Prof. Anim. Indus., Univ. Cal., and Anim. Husb., Calif. Expt. Sta., '12–'13; Senior Anim. Husb., Bur. Anim. Indus., U. S. D. A., '13—.

1911—David William May, B. Agr. (Univ. Mo., '94), M. Agr. (do., '96); *Mayaguez, P. R.;* Asst. Agr., Missouri Expt. Sta., '97; Sci. Asst. Office Expt. Stas., U. S. D. A., '00–'02; Anim. Husb., Ky. Expt. Sta., '02–'04; Special Agt. in charge, P. R. Expt. Sta., '04—.

1905—Lucius Herbert Merrill, B. S. (Univ. Me., '83), D. Sc. (honorary, do., '08); *Orono, Me.;* Chem., Me. Expt. Sta., '86–'08; Prof. Biol. Chem., Univ. Me., '98–'07; Prof. Biol. and Agr. Chem., do., '07—.

1909—Merritt Finley Miller, B. S. Agr. (Ohio State Univ., '00), M. S. A. (Cornell Univ., '01); *Columbia, Mo.;* Asst. Bur. Soils, U. S. Dept. Agr., '01-'02; Instr. Agron., Ohio State Univ., '02–'03; Asst. Prof., do., '03–'04; Prof. Agron., and Agron., Univ. Mo. and Expt. Sta., '04—.

1916—George Edwin Morton, B. S. (Colo. Agr. Coll., '04), M. L. (Milton coll., Wis., '04); Asst. and Prof. An. Husb., Univ. of Wyo., '04–'07; Prof. An. Husb., Colo. Agr. Coll., '07–'08; Head An. Husb., Dept., do., '08—; Colo, State Dairy Comnr., '13—.

1900—John Harcourt Alexander Morgan, B. S. A. (Univ. Toronto, '89); *Knoxville, Tenn.;* Prof. Ento. and Hort., La. State Univ., '89–'93; Prof. Zool. and Ento., do., '93–'04; Ento., La. Expt. Stas., '89–'04; Dir. Gulf Biol. Sta., '99–'05; Dir. Tenn. Expt. Sta., '05—.

1911—Fred Winslow Morse, B. S. (Worcester, '87), M. S. (do., '00); *Amherst, Mass.;* Asst. Chem., Mass. Expt. Sta., '87–'88; do., N. H. Expt. Sta., '88–'89; Chem., do., '89–'09; Vice Dir., do., '96–'09; Prof. Chem., N. H. Agr. Coll., '90–09; Research Chem., Mass. Expt. Sta., '10—.

1912—Warner Jackson Morse, B. S. (Univ. Vt., '98), M. S. (do., '03), Ph. D. (Univ. Wis., '12); *Orono, Me.;* Teach. Nat. Sci., Montpelier Seminar, '99–'01; Asst. Bot., Vt. Expt. Sta., '01–'06; Instr. Bot., do., '01–'05; Asst. Prof. Bact., do., '05–'06; Plant Path, Me., Expt. Sta., '06—.

1909—Frederick Blackmar Mumford, B. S. (Mich. Agr. Coll., '91), M. S. (do., '93); *Columbia, Mo.;* Asst. Mich. Expt. Sta., '91–'95; Asst. Prof. Agr., Mich. Agr. Coll., '93–'95; Prof. Agr., Univ. Mo., '95–'04; Acting Dean Coll. Agr., Univ. Mo., and Acting Dir., Mo. Expt. Sta., '03–'05; Prof. Anim. Husb., Univ. Mo., '04—; in charge Anim. Husb. Dept., Mo. Expt. Sta., '06—; Dean Agr. and Dir. Expt. Sta., '09—.

1901—Herbert Windsor Mumford, B. S. (Mich. Agr. Coll., '91); *Urbana, Ill.;* Instr., Mich. Agr. Coll., and Asst., Expt. Sta., '95–'96; Asst. Prof. Agr. and Anim. Husb., do., '96–'99; Prof. Agr., do., '99–'01; Prof. Anim. Husb., Univ. Ill., and Chief in Anim. Husb., Ill. Expt. Sta., '01—.

1913—Martin Nelson, B. S. A. (Univ. Wis., '05), M. S. (do., '06); *Fayetteville, Ark.;* Adj. Prof. Field Crops and Soils, Univ. Nebr. and Expt. Sta., '06–'07; Asst. Prof. do., '07–'08; Prof. Agron. and Agron., Univ. Ark. and Expt. Sta., '08–'13; Dean Univ. Ark. and Dir. Expt. Sta., '13—.

1893—Herbert Osborn, B. S. (Iowa State Coll., '79), M. S. (do., '80); *Columbus, Ohio;* Asst. Zool. and Ento., Iowa State Coll., '79–'83; Asst. Prof., do., '83–'85; Prof., do., '85–'98; Prof. Zool. and Ento., Ohio State Univ., '98—.

1893—Louis Herman Pammel, B. Agr. (Univ. Wis., '85), M. S. (do., '89), Ph. D. (Wash. Univ., '99); *Ames, Iowa;* Asst., Shaw School of Bot., '86–'89; Tex. Agr. Expt. Sta., '89; Prof. Bot., Iowa State Coll., '89—; Bot., Iowa Expt. Sta., '92—.

1893—Henry Jacob Patterson, B. S. (Pa. State Coll., '86); *College Park, Md.;* Asst. Chem., Pa. Expt. Sta., '86–'88; Chem., Md. Expt. Sta., '88–'98; Dir. and Chem., do., '98; Pres. Md. Agr. Coll., '13—.

1910—Raymond Pearl, A. B. (Dartmouth Coll., '99), Ph. D. (Univ. Mich., '02); *Orono, Me.;* Asst. Zool., Univ. Mich., '99–'02; Instr. Zool., do., '02–'06; Instr. Zool., Univ. Penn., '06–'07; Biol. and Head Dept. Biol., Me. Expt. Sta., '07—; Assoc. Ed. *Zool. Jahresber*, '06–'08; *Biometrika*, '06–'10; *Zentbl. Alig. u Expt. Biol.*, '10—.

1909—Raymond Allen Pearson, B. S. A., (Cornell Univ., '94), M. S. A. (do., '99); *Ames, Iowa;* Asst. Chief Dairy Div., U. S. Dept. Agr., '95–'02; Mgr. Walker-Gordon Lab. Co., N. Y. and Phila., '02–'03; Prof. Dairy Ind., Cornell Univ., '03–07; N. Y. Comr. Agr., '07–'12; Pres. Iowa State Coll., '12—.

1910—William Robert Perkins, B. S. (Miss. Agr. Coll., '91); M. S. (do., '94); *Baton Rouge, La.;* Asst. State Chem., Miss., '91–'94; Chem., Miss. Expt. Sta., '94–'06; Asst. Prof. Agr., Miss. Agr. Coll., '06; Agron., Miss. Expt. Sta., '07–'10; Dir. Agr. Dept., and Prof. Agron., Clemson Coll., '10–'11; Supt. Syndicate Farm, Deeson, Miss., '11—.

1909—Charles Vancouver Piper, B. S. (Univ. Wash., '85), M. S. (do., '92; Harvard, '00); *Washington, D. C.;* Prof. Ento., Wash. State Coll., '92–'93; Prof. Bot. and Zool., do. and Bot. and Ento., Expt. Sta., '93–'03; Syst. Agrostrologist, U. S. Dept. Agr., '03–04; Agrostologist, do., '05—.

1890—Charles Sumner Plumb, B. S. (Mass. Agr. Coll., '82); *Columbus, Ohio;* Asst. Ed. *Rural New Yorker*, '83–'84; First Asst., N. Y. Expt. Sta., '84–'87; Prof. Agr., Univ. Tenn., and Asst. Dir., Expt. Sta., '87–'90; Prof. Agr. Sci., Purdue Univ., '90–'94; Prof. Anim. Indus. and Dairying, do., '94–'00; Prof. Anim. Indus., do., '00–'02; Vice Dir., Ind. Expt. Sta., '90–'91; Dir., do., '91–'02; Prof. Anim. Indus., Ohio State Univ., '02—

1894—Frank William Rane, B. Agr. (Ohio State Univ., '91), M. Sc. (Cornell Univ., '92); *State House, Boston, Mass.;* Hort. and Microscopist, W. Va. Expt. Sta., '92–'95; Prof. Agr. and Hort., W. Va. Univ., '93–'95; Prof. Agr. and Hort., N. H. Coll., '95–'98; Prof. Hort., do., '98–'00; Prof. Forestry and Hort, do., '00–'06; State Forester, Mass., '06—.

1913—JAMES BURNESS RATHER, B. S. (Tex. Agr. Coll., '07), M. S. (do., '11), A. M. (Johns Hopkins Univ., '15); *Fayetteville, Ark.;* Asst. State Chem. Tex., '07–'09; Asst. Chem., Tex. Expt. Sta., '08–'12; First Asst. Chem., do., '12–'14; Prof. of Agr. Chem. and Chem. to Expt. Sta., Coll. of Agr., Univ. of Ark., '15—.

1913—GEORGE MATTHEW REED, A. B. (Geneva Coll., '00), A. M. (Univ. Wis., '04), Ph. D. (do., '07); *Columbia, Mo.;* Prof. Nat. Sci., Amity Coll., '00–'03; Asst. in Bot., Univ. Wis., '04–'07; Instr. in Bot., do., '07; Asst. Prof. Bot., Univ. Mo., '07–'12; Prof. Bot., do., '12—; Bot., Mo. Expt. Sta., '09—.

1881—ISAAC PHILLIPS ROBERTS. M. Agr. (Iowa State Coll., '75, *731 Cameron Avenue, Fresno, Cal.;* Prof. Agr. and Dean Agr., Cornell Univ., '73–'94; Dir. Cornell Expt. Sta., '88–'03; Dir. Coll. Agr., '94–'03; Prof. Emeritus, lecturer and author, '03—.

1893—JAMES WILSON ROBERTSON, LL. D. (Toronto Univ. and Queen's Univ., '03; Univ. New Brunswick, '04); *Box 540, Ottawa. Can.;* Prof. Dairying, Ontario Agr. Coll., '86–'90; Dairy Comr. Canada, '90–'95; Comr. Agr. and Dairying, '95–'04; Prin., MacDonald Coll., '05–'09; Chairman Royal Com. on Indus. Training and Tech. Ed., '10—.

1909—PETER HENRY ROLFS, B. S., M. S. (Iowa State Coll., '91); *Gainesville, Fla.;* Asst. Bot., Iowa State Coll., '91; Ento. and Bot., Fla. Expt. Sta., '92–'98; Bot. and Hort., do., '98–'99; Bot. and Bact., S. C. Expt. Sta., '99–'01; Plant Path. in charge Sub-Trop. Lab., U. S. Dept. Agr., Miami, Fla., '01–'06; Dir., Fla. Expt. Sta., '06—; State Supt. Farmers' Institutes, '07—.

1911—GEORGE MCCULLOUGH ROMMEL, B. S. (Iowa Wesleyan Univ., '97), B. S. A. (Iowa State Coll., '99); *Washington, D. C.;* Expert in Anim. Husb., do., '05–'09; Chief. Anim. Husb. Div., do., '10–.

1909—HARRY LUMAN RUSSELL, B. S., (Univ. Wis., '88), M. S. (do., '90), Ph. D. (Johns Hopkins, '92); *Madison. Wis.;* Fellow, Univ. Wis., '88–'90; Fellow, Univ. Chicago, '92–'93; Asst. Prof. Bact., Univ. Wis., '93–'96; Prof., do., '96–'97; Bact., Wis. Expt. Sta., '93–'97; Dir. State Hygienic Lab., '03–'07; Dean Coll. of Agr. and Dir. Expt. Sta., Univ. Wis., '07—; Dir., Agr. Ext., '14—.

1912—WALTER GEORGE SACKETT, B. S. (Univ. Chicago, '02); *Fort Collins, Colo;* Prof. Nat. Sci., Meredith Coll., '02–'04; Special Agt., U. S. Dept. Agr., '04; Instr. Bact. and Hyg., Mich. Agr. Coll., '04–'06; Asst. Prof. and Hyg., do., and Asst. Bact. Mich. Expt. Sta., '06–'08; Bact., Colo. Expt. Sta., '08—.

1908—EZRA DWIGHT SANDERSON, B. S. (Mich. Agr. Coll., '97), B. S. Agr. (Cornell, '98); *Chicago, Ill.;* Asst. State Ento. Md., '98–'99; Ento., Del. Expt. Sta., and Assoc. Prof. Zool., Del. Coll., '99–'02; State Ento., Tex., and Prof. Ento., Tex. A. and M. Coll., '02–'04; Ento., N. H. Expt. Sta., and Prof. Ento., and Zool., N. H. Coll., '04–'09; Dir. N. H. Expt. Sta., '07–'09; Dean Coll. Agr., W. Va. Univ., '10–'15; Dir., W. Va. Expt. Sta., '12–'15; Student, Univ. Chi., '15—.

1910—Robert Sidney Shaw, B. S. (Ontario Agr. Coll., '93); *East Lansing, Mich.;* Asst. Agr. Mont. Agr. Coll. and Expt. Sta., '97–'02; Prof. Agr., Mich. Agr. Coll., '02–08; Dean Agr., do., and Dir. Expt. Sta., '08—.

1893—Thomas Shaw, *2135 Knapp Street, St. Paul, Minn.;* Prof. Agr., Ontario Agr. Coll., '88–'93; Prof. Anim. Husb., Minn. Coll. Agr., '93–'03; Ed. *Farmer*, '03–'08; Northwest Ed. Orange Judd Publications, '08—.

1898—John Henry Shepperd, B. Agr. (Iowa State Coll., '91), M. S. A. (Univ. Wis., '93); *Agricultural College, N. Dak.;* Ed. Staff *Orange Judd Farmer*, '93; Prof. Agr., N. Dak. Agr. Coll., and Agriculturist Expt. Sta., '93–'04; Dean and Vice Dir., '04—.

1909—John Harrison Skinner, B. S. (Purdue Univ., '97); *Lafayette, Ind.;* Asst. Agr., Ind. Expt. Sta., '99–'01; Anim. Husb., Univ. Ill., '01–'02; Assoc. Prof. Anim. Husb., Purdue Univ., '02–'06; Prof., do., '06; Dean Agr. Dept., Purdue Univ., '07—.

1907—Howard Remus Smith, B. Sc. (Mich. Agr. Coll., '95); *University Farm, St. Paul, Minn.;* Teacher, Tilford Collegiate Acad. and Rock Island High School, '95–'09; Acting Prof. Agr., Univ. Mo., '00–'01; Asst. Prof. Anim. Husb., Univ. Nebr., '01; Assoc. Prof., do., '02; Prof., do., '03–'12; Anim. Husb., Univ. Minn., '12–'14.

1899—Harry Snyder, B. S. (Cornell Univ., '89); *1800 Summit Ave., Minneapolis, Minn.;* Asst. Chem., Cornell Univ. Expt. Sta., '90–'91; Asst. Instr. Qual. Anal., do., '89–'90; Prof. Agr. Chem., Univ. Minn., and Chem., Expt. Sta., '91–'09; Chem., Russell Miller Milling Co., '09—.

1909—Andrew McNairn Soule, B. S. (Univ. Toronto, '93), Sc. D. (honorary, Univ. Ga., '10); *Athens, Ga.;* Asst. Dir. Mo. Expt. Sta., '94; Asst. Prof., Agr. and Asst. Agriculturist, Tex. Agr. Coll. and Expt. Sta., '94–'99; Dir. Tenn. Expt. Sta. and Chairman Agr. Faculty, Univ. Tenn., '99–'04; Dean of Agr. and Dir. Expt. Sta., Va. Poly. Inst., '04–'07; Pres. Coll. Agr., Univ. Ga., '07—.

1903—William Jasper Spillman. B. S. (Univ. Mo., '86), M. S. (do., '89), Sc. D. (do., '10); *Washington, D. C.;* Prof. Sci., Mo. State Normal, '87–'89; Prof. Sci., Vincennes Univ., '89–'91; Prof. Sci., Ore. State Normal, '91–'94; Prof. Agr., State Coll. Wash, '94–'01; Agrostologist, U. S. Dept. Agr., '01–'04; Agriculturist in charge Farm Management, do., '04—.

1911—Frank Lincoln Stevens, B. L. (Hobart, '91), B. S. (Rutgers Coll., '93), M. S. (do., '97); Ph. D. (Univ. Chicago, '00), *Urbana. Ill.;* Teacher of Sci., Racine Coll., '93–'94; do., Columbus, O., High School, '94–'97; Instr. in Biol., N. C. Agr. Coll., '00–'02; Prof. Bt. and Veg. Path., do., '03–'11; Biol., N. C. Expt. Sta., '03–'11; Dean, P. R. Coll. Agr., '12–'14; Prof. Plant Path., Univ. Ill., '14—.

1917—Robert Stewart, B. S., (Utah Agr. Coll., '02), Ph. D. (Univ. of Ill., '09); Prof. of Chem. and Asst. Dir. of Utah Agr. Expt. Sta., '08–'15; Assoc. Prof. Soils and Assoc. Chief in Soil Fertility, Expt. Sta., Univ. of Ill., '15—.

1908—William Alton Taylor, B. S. (Mich. Agr. Coll., '88), D. Sc. (do., '13); *Washington, D. C.;* Asst. Pomol., U. S. Dept. Agr., '91–'01; Pomol. in charge Field Investigations, '01–'10; Asst. Chief, Bur. Plant Indus., '11–'13; Chief, do., '13—.

1911—Roscoe Wilfred Thatcher, B. Sc. (Univ. Nebr., '98), M. A. (do., '01); *University Farm, St. Paul, Minn.;* Asst. Chem., Nebr. Expt. Sta., '99–'01; Asst. Chem., Wash. Expt. Sta., '01–'03; Chem., do., '03–'12; Asst. Prof. Chem., State Coll. Wash., '04–'06; Assoc. Prof. do., '06–'10; Prof. Agr. Chem. and Head of Dept. Agr., do., '10–'13; Dir. Wash. Expt. Sta., '07–'13; Prof. Agr. Chem. and Agr. Chem., Univ. Minn. and Expt. Sta., '13-'17; Dean, Dept. Agr., Univ. of Minn. and Dir. Expt. Sta., '17—.

1907—Charles Embree Thorne, M. Agr. (Ohio State Univ., '90); *Wooster, Ohio;* Dir. Ohio Expt. Sta., '87—.

1910—Edward Gaige Titus, B. S. (Colo. Agr. Coll., '99); M. S. (do., '01), D. Sc. (Harvard, '11); *Logan, Utah;* Asst. Dept. Zool. and Ento., Colo. Agr. Coll., '00–'01; Field Asst. State Ento., Ill., '01–'03; Spec. Agt., Bur. Ento., U. S. Dept. Agr., '03–'07; Prof. Zool. and Ento., Utah Agr. Coll. and Ento. Expt. Sta., '07—.

1901—Charles Orrin Townsend, B. S. (Univ. Mich., '88), M. S. (do., '91), Ph. D. (Leipsic, '97); *Washington, D. C.;* Prof. St. Johns Coll., Md., '88–'91; Prof. Sci., Wesleyan Coll., Ga., '91–'95; Instr. Bot., Barnard Coll., '98; Prof. Bot. Md. Agr. Coll., and State Plant Path., Md., '98–'01; Path. Bur. Plant Indus., U. S. Dept. Agr., '01–'10; do., '12—; Consulting Agr., U. S. Sugar and Land Co., '10–'12.

1881—Samuel Mills Tracy, B. A. (Mich. Agr. Coll., '68), M. S. (do., '76); *Biloxi, Miss.;* Asst. Prof. Agr., Mo. State Univ., '77–'80; Prof. Bot. and Hort., do., '80–'87; Dir. Miss Expt. Sta., '87–'97; Spec. Agt. U. S. Dept. Agr., '97—.

1894—William Trelease, B. S. (Cornell, '80), D. Sc. (Harvard, '84), LL. D. (Wis., '02; Mo., '03; Wash. Univ., '07); *Urbana, Ill.;* Prof. Bot., Univ. Wis., '83–'85; Englemann Prof. Bot. and Dir. Shaw School Bot., Wash. Univ., '85—; Dir. Mo. Bot. Gard., '89–'12; Research Work, '12–'13; Prof. Bot., Univ. Ill., '13—.

1913—Perry Fox Trowbridge, B. Pd. (Mich. Norm. Coll., '92), Ph. B. (Univ. Mich., '92), A. M. (do., '05), Ph. D. (Univ. Ill., '06), M. Pd. (Mich. Norm. Coll., '11); *Columbia, Mo.;* Instr. Chem., Univ. Mich., '94–'02; Sugar Chem., do., '02–'05; Research Asst. and Instr. in Chem., Univ. Ill., '05–'07; Agr. Chem. and Assoc. Chem., Univ. Mo. and Expt. Sta., '07–08; Prof. and Chem., do., '08—.

1907—ALFRED CHARLES TRUE, B. A. (Wesleyan Univ., Conn., '73), M. A. (do., '76), Ph. D. (Erskine Coll., S. C., '86), D. Sc. (Wesleyan Univ., '06); *Washington, D. C.;* Prin. High School, Essex, N. Y., '73–'75; Instr. State Normal School, Westfield, Mass., '75–'82; Grad. Stud., Harvard Univ., '82–'84; Instr., Wesleyan Univ., '84–'88; Ed., U. S. Office Ext. Stas., '88–'91; Asst. Dir., do., '91–'93; Dir., do., '93–'14; Dir., States Relations Service, U. S. D. A., '14—.

1914—HUBERT EVERETT VAN NORMAN, B. S. (Mich. Agr. Coll., '97); *Davis, Calif.;* Mgr. Dairy Farm, '97–'98; Supt. Univ. Farm, Purdue Univ., '98–'02; Chief, Dairy Dept., Purdue Univ., '02–'05; Prof. Dairy Husb., Pa. St. Coll., '05–'13; Prof. Dairy Mgmt., Univ. of Calif., '13—; Vice Dir., Agr. Expt. Sta. and Dean, Univ. Farm School, '13—.

1908—ALFRED VIVIAN, Ph. G. (Univ. Wis., '94); *Columbus, Ohio;* Instr. Phar., Univ. Wis., '94–'95; Asst. Agr. Chem., do., '95–'97; Instr., do., and Asst. Chem., Expt. Sta., '97–'02; Assoc. Prof. Agr. Chem., Ohio State Univ., '02–'05; Prof. Agr. Chem., do., '05—.

1912—JOHN FRANCIS VOORHEES, B. S. A. (Univ. Tenn., '09), M. S. A. (do., '11); *Knoxville, Tenn.;* Asst. Observ., U. S. Weather Bur., New Orleans, La., '01; do., Knoxville, Tenn., '02–'05; Observ. in charge Knoxville Sta., '06—; Instr. in Met. and Consult Met., Univ. Tenn. and Expt. Sta., '09—.

1893—HENRY JACKSON WATERS, B. Agr. (Univ. Mo., '86); *Manhattan, Kans,;* Asst. Agr., Mo. Expt. Sta., '87–'91; Prof. Pa. State Coll., '92–'95; Dean Coll. Agr. and Dir. Expt. Sta., Univ. Mo.. '96–'09; Pres. Kans. State Agr. Coll., '09—.

1914—RALPH LEVI WATTS, B. A. (Pa. State Coll., '90), M. S. (do., '99); *State College, Pa.;* Hort. of Tenn. Expt. Sta., '90–'99; Lecturer, Farmers Institutes, Pa., Md., N. J., '99–'08; Prof. of Hort., Pa. St. Coll., '08–'12; Acting Dean and Dir. School of Agr. and Expt. Sta., do., '12–'13; Dean and Dir., do., '13—.

1910—HERBERT JOHN WEBBER, B. Sc. (Univ. Nebr., '89); M. A. (do., '90), Ph. D. (Wash. Univ., St. Louis, '00); *Riverside, Cal.;* Asst. in Bot., Univ. Nebr., '89–'90; Asst., Shaw School of Bot., '90–'92; Physiol., U. S. Dept. Agr., '92–'97; in charge Plant Breeding Lab., do., '97–'07; Prof. Expt. Plant Breeding, Cornell Univ., '07–'12; Dir., Citrus Expt. Sta., and Dean, Grad. School Trop. Agr., Univ. Cal., '13—.

1896—JULIUS BUELL WEEMS, B. Sc. (Md. Agr. Coll., '88), Ph. D. (Clark Univ., '94); *South Boston, Va.;* Instr. Chem. and Math., Md. Agr. Coll., '88–'89; Con. Chem., do., '91–'92; Prof. Agr. Chem. and Chem. Expt. Sta., Iowa State Coll., '95–'04; Industrial Chem., '04—.

1904—HOMER JAY WHEELER, B. Sc. (Mass. Agr. Coll. and Boston Univ., '83), Ph. D. (Univ. Gottingen, '89), D. Sc. (Brown, '11); *92 State St., Boston, Mass.;* Asst. Chem., Mass. Expt. Sta., '83–'87; Chem.,

R. I. Expt. Sta., '89–'08; Prof. Geol., R. I. Coll., '89–'12; Prof. Agr. Chem., do., '03–'10; Acting Pres., do., '02–'03; Dir. Expt. Sta., do., '01–'12; Agron., do., '05–'12; Expert, Amer. Agr. Chem. Co., '12—.

1889—MILTON WHITNEY, *Washington, D. C.;* Asst. Chem., Conn. Expt. Sta., '83; Supt. Expt. Farm., N. C. Expt. Sta., '86–'88; Prof. Agr., S. C. Coll., and Vice Dir., Expt. Sta., '88–'91; Soil Physicist. Md. Expt. Sta.. '91–'94; Prof. Soil Physics, Md. Agr. Coll., '94–'01; Chief Bur. Soils, U. S. Dept. Agr., '94—.

1898—JOHN CHARLES WHITTEN, B. S. (S. Dak. Agr. Coll., '91), M. S. (do., '99), Ph. D. (Univ. Halle, '02); *Columbia, Mo.;* Instr. in Hort. and Hort. Expt. Sta., S. Dak. Agr. Coll., '92; Asst. in Hort., Mo. Bot. Gard., '93–'94; Prof. Hort. and Hort. Expt. Sta., Univ. Mo., '94—.

1911—JOHN ANDREAS WIDTSOE, B. S. (Harvard Univ., '94), Ph. D. (Univ. Gottingen, '99); *Logan, Utah;* Chem., Utah Expt. Sta., '94–'05; Prof. Chem., Utah Agr. Coll., '95–'05; Dir. Utah Expt. Sta., '00–'05; Dir. School of Agr., Brigham Young Univ., '05–'07; Pres., Utah Agr. Coll., '07—.

1912—JULIUS TERRASS WILLARD, B. S. (Kans. Agr. Coll., '83), M. S. (do., '86), D. Sc. (do., '08); *Manhattan, Kans.;* Asst. in Chem. Kans. Agr. Coll., '83–'87; Asst. Prof. Chem., do., '90–'96; Assoc. Prof. Chem., do., '96–'97; Prof. Appl. Chem., do., '97–'01; Prof. Chem., do., '01—; Dean, Div. Gen. Sci., do., '09—; Asst. Chem., Kans. Expt. Sta., '88–'97; Chem., do., '97—; Dir., do., '00–'06; Chem., Kans. Engin. Expt. Sta., '10—.

1912—CHARLES BURGESS WILLIAMS, B. S. (N. C. Agr. Coll., '93), M. S. (do., '96); *West Raleigh, N. C.;* Asst. Chem., N. C. Dept. Agr., '93–'06; Agron., do., '06–'07; Dir. and Agron., N. C. Expt. Sta., '07–'12; Vice Dir. and Agron., do., '13—.

1908—CARLOS GRANT WILLIAMS, *Wooster, Ohio;* Agron., Ohio Expt. Sta., '03—.

1911—WILLIAM ALPHONSO WITHERS, A. B. (Davidson Coll., '83), A. M. (do., '85); Grad. Stud. Cornell Univ., '88–'90; Fellow ib., '89–'90; *West Raleigh, N. C.;* Asst. Chem., N. C. Expt. Sta., '84–'88; Prof. Chem., N. C. Agr. Coll., '89—; Statis. Agt., U. S. Dept. Agr., '95–'02; Acting Dir., N. C. Expt. Sta., '97–'99; Chem., do., '97—.

1909—FRITZ WILHELM WOLL, B. S. (Royal Fredericks Univ., Christiania, '82), Ph. B. (do., '83), M. S. (Univ. Wis., '86), Ph. D. (do., '04); *Davis, Calif.;* Asst. Chem., Wis. Expt. Sta., '87–'97; Chem., do., '97–'13; Asst. Prof. Agr. Chem., Univ. Wis., '93–'04; Assoc. Prof., do., '04–'06; Prof., do., '06–'13; Prof. Anim. Nutr., Univ. Cal. and Expt. Sta., '13—.

1903—ALBERT FREDERICK WOODS, B. Sc. (Univ. Nebr., '90), A. M. (do., '92), D. Agr. (do., '13); *University Farm, St. Paul, Minn.;* Asst. Bot., Univ. Nebr., '91–'94; Asst. Chief Div. Veg. Path., U. S. Dept. Agr., '94–'00; Chief, do., '01–'09; Asst. Chief, Bur. Plant Indus., do., '01–'09; Dean Coll. of Agr. ,Univ. Minn., and Dir. Expt. Sta., '10—.

1903—Charles Dayton Woods, B. S. (Wesleyan Univ., Conn., '80), D. Sc. (honorary, Univ. Me., '05); *Orono, Me.;* Asst. Chem., Wesleyan Univ., '80–'85; Instr. Sci., Wilbraham Acad., Mass., '83–'88; Chem., Conn. Storrs Expt. Sta., '88–'96; Vice Dir., do., '89–'96; Prof. Agr., Univ. Me., '86–'03; Dir. Maine Expt. Sta., '96—.

1916 Daniel Webster Working, B. S. (Kans. State Agr. Coll., '88), M. S. (Univ. of Denver, Colo., '07); Lecturer, Colo. State Grange, '90–'91 and '94–'95; Master Colo. State Grange, '92–'93; Secy. Colo. State Board of Agr. and Agr. Coll., '93–'97; County Supt. Schools of Araphoe County, Colo., '05–'07; Supt. Agr. Exten. Work, W. Vir. Univ., '07–'11; Office Farm Mgmt. and Ext. Work in North and West, U. S. D. A., '11—.

1911—Bonney Youngblood, B. S. (Tex., Agr. Coll., '02, M. S. (do., '07); *College Station, Tex.;* Prin. and Instr. in Agr., Henderson, Tex., City Schools, '03–'05; Prin. and Instr. in Agr., Mineola, Tex., High School, '05–'06; Supt. City Schools and Instr. in Agr., Pauls Valley, Okla., '06–'07; Asst. Agr., Office of Farm Management, U. S. Dept. Agr., '07–'11; Dir., Tex. Expt. Sta., '11—.

1910—C. A. Zavitz, B. Sc. (Toronto Univ., '88); *Guelph, Canada;* Asst. Expt. Dept., Ontario Agr. Coll., '86–'93; Head of Expt. Dept., '93—; Prof. of Field Husbandry, Ontario Agr. Coll., '04—.

DECEASED MEMBERS

Robert Fairchild Kedzie..........	Born Dec. 9, 1852	Died Feb. 13, 1882
Lauren Briggs Arnold.............	" Aug. 13, 1814	" Mar. 7, 1888
George Hammel Cook.............	" Jan. 5, 1818	" Sept. 22, 1889
Patrick Barry....................	" May 24, 1816	" June 24, 1890
John J. Thomas..................	" Jan. 8, 1818	" Feb. 22, 1895
Charles Valentine Riley...........	" Sept. 18, 1843	" Sept. 14, 1895
Charles Lee Ingersoll.............	" Nov. 1, 1844	" Dec. 15, 1895
Edward Louis Sturtevant.........	" Jan. 23, 1842	" July 30, 1898
Sir John B. Lawes, *Hon. Mem*.....	" Dec. 28, 1814	" Aug. 31, 1900
John Alvah Myers................	" May 28, 1853	" April 8, 1901
Sir Henry Gilbert, *Hon. Mem*......	" Aug. 1, 1817	" Dec. 23, 1901
Robert Clark Kedzie..............	" Jan. 28, 1883	" Nov. 27, 1902
Victor Hunt Lowe................	" Sept. 23, 1869	" Aug. 27, 1903
Henry English Alvord.............	" Mar. 11, 1844	" Oct. 1, 1905
Robert Warington, *Hon. Mem*.....	" Aug. 22, 1838	" Mar. 20, 1907
Willis Grant Johnson..............	" July 4, 1866	" Mar. 11, 1908
James Fletcher...................	" Mar. 28, 1852	" Nov. 8, 1908
Samuel William Johnson..........	" July 3, 1830	" July 21, 1909
William Henry Brewer............	" Sept. 14, 1828	" Nov. 2, 1910
Charles Anthony Goessmann......	" June 13, 1827	" Sept. 1, 1910
Samuel B. Green.................	" Sept. 15, 1859	" July 11, 1910
Welton M. Munson................	" April 8, 1866	" Sept. 9, 1910
Edward Burnett Voorhees.........	" June 22, 1856	" June 6, 1911
Franklin Hiram King.............	" June 8, 1848	" Aug. 4, 1911
Oskar Kellner, *Hon. Mem*.........	" May 13, 1851	" Sept. 22, 1911
John Bernhardt Smith............	" Nov. 21, 1858	" Mar. 12, 1912
Melville Amasa Scovell...........	" Feb. 26, 1855	" Aug. 15, 1912
Charles Edwin Bessey............	" May 21, 1845	" Feb. 25, 1915
Eugene Waldemar Hilgard........	" Jan. 5, 1833	" Jan. 8, 1916
Joseph Hoeing Kastle.............	" Jan. 25, 1864	" Sept. 24, 1916
William Rane Lazenby............	" Dec. 5, 1850	" Sept. 15, 1916
C. D. Smith......................	" Mar. 7, 1854	" Aug. 1, 1916
Robert Hills Loughridge..........	" Oct. 9, 1843	" July 1, 1917

PROCEEDINGS

OF THE

THIRTY-NINTH ANNUAL MEETING

OF THE

Society for the Promotion of Agricultural Science

BALTIMORE, MD.

January 6 and 7, 1919

EDITED BY THE SECRETARY

PUBLISHED BY THE SOCIETY
1919

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CONTENTS

OFFICERS OF THE SOCIETY FOR 1919

President

R. W. Thatcher .... St. Paul, Minn.

Vice-President

B. L. Hartwell .... Kingston, R. I.

Secretary-Treasurer

J. G. Lipman .... New Brunswick, N. J.

Custodian

W. D. Hurd .... Amherst, Mass.

Executive Committee

David Fairchild .... Washington, D. C.
W. R. Dodson .... Baton Rouge, La.
F. B. Linfield .... Bozeman, Mont.

Past Presidents

Term began		*Expired*
1880	W. J. Beal, *of Michigan*	1882
1881	W. H. Brewer, *of Connecticut*	1884
1884	H. E. Alvord, *of New York*	1886
1886	E. L. Sturtevant, *of New York*	1887
1887	R. C. Kedzie, *of Michigan*	1889
1889	C. E. Bessey, *of Nebraska*	1891
1891	I. P. Roberts, *of New York*	1893
1893	W. Saunders, *of Ontario, Canada*	1895
1895	W. R. Lazenby, *of Ohio*	1897
1897	B. D. Halsted, *of New Jersey*	1899
1899	W. J. Beal, *of Michigan*	1901
1901	W. H. Jordan, *of New York*	1903
1903	William Frear, *of Pennsylvania*	1905
1905	H. P. Armsby, *of Pennsylvania*	1907
1907	T. F. Hunt, *of Pennsylvania*	1909
1909	S. M. Tracy, *of Mississippi*	1911
1911	Eugene Davenport, *of Illinois*	1913
1913	H. J. Waters, *of Kansas*	1915
1915	Charles E. Thorne, *of Ohio*	1916
1916	Herbert Osborn, *of Ohio*	1919

Past Secretaries

1880	E. L. Sturtevant, *of Massachusetts*	188
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Minutes of the 39th Annual Meeting of the Society For the Promotion of Agricultural Science

Held at Baltimore, Maryland, January 6 and 7, 1919

The first session on the evening of January 6 was held in the Ball Room of the Southern Hotel in conjunction with the American Society of Agronomy, for the purpose of hearing the addresses of the presidents of the two societies and an address by Dr. W. O. Thompson, president of the Ohio State University, who gave an account of his recent trip through France, England and Italy as Agricultural Commissioner from the United States.

The sessions on January 7 were held at Hotel Rennert. They were called to order by the president, Dr. Herbert Osborn, and continued throughout the day with a good attendance.

At the opening of the morning session the following business was transacted:

The report of the secretary-treasurer was read and an auditing committee consisting of Dr. E. W. Allen and Prof. F. W. Rane was appointed.

On motion by Dr. E. W. Allen, the president appointed E. W. Allen, L. A. Clinton and C. E. Thorne as a nomination committee.

After a considerable discussion upon the future work of the society it was moved and carried that we recommend to the executive committee that the next annual meeting be held in conjunction with the A. A. A. S. unless, in their judgment, there are good reasons why other arrangements should be made.

It was moved and carried that the secretary be requested to live up to the rule of the society that no paper be included in the proceedings of the society that has not first been approved by the executive committee.

A motion was passed inviting those who were candidates for membership in the society and who have papers they would like to read, to present them at this meeting.

The secretary reported that he did not care to put in a bill for th salary voted at the last meeting as he did not think the finances of th society would warrant his doing so. He also stated that he ha invested only $150 in Liberty Bonds, instead of $200 as he was in structed to do last year, because of the small amount of money lef in the treasury.

The committee on nominations reported as follows:

For President, R. W. Thatcher, St. Paul, Minn.

For Vice-President, B. L. Hartwell, R. I. Exp. Sta.

For Secretary-Treasurer, J. G. Lipman, New Brunswick, N. J.

For Custodian, W. D. Hurd, Amherst, Mass.

For Executive Committee, F. B. Linfield, Bozeman, Mont.

On motion, the secretary cast the unanimous ballot of the societ for the above mentioned nominees as officers of the society for th ensuing year.

The names of Henry J. Wilder, States Relation Service, Unite States Department of Agriculture; R. W. Clothier, Office of Farm Management, United States Department of Agriculture, and W. W Robbins, Colorado Agricultural College, were presented for membership, and being recommended by the executive committee wer duly received.

The auditing committee reported that they found the accounts o the treasurer correct and that there was a balance in the treasur of $102.71, besides $150 in Liberty Bonds. There was, in addition a statement from the custodian, W. D. Hurd, showing a balance i his hands of $72.68 from sales of Proceedings, which had not bee turned over to the secretary.

The following program of papers was then presented:

The Problem of Permanent Pasture, With Special Reference to the Biological Factors

PRESIDENTIAL ADDRESS

HERBERT OSBORN
Ohio State University, Columbus, O.

It is hardly necessary in an agricultural assembly to argue the place of the meadow or pasture in a system of agriculture. Even the most ardent advocate of intensive agriculture, which means intensive cultivation, must reserve a place for the forage necessary for domestic animals, and while there may be an effort to crowd the meadow and pasture farther and farther back upon the cheaper and less tillable lands, no one, I think, will argue seriously for their elimination.

The problem of adequate pasturage, however, appears to me to be concerned not merely with the immediate supply of grazing area for livestock but to have some very important relations to general community and national welfare. Moreover, the problem connected with the maintenance of meadows and pastures small or large, under conditions of intensive agriculture or the unimproved range, have in them so many biological factors that are of significance to students of nature as well as to agriculturists that a survey of the subject from the purely biological viewpoint would be warranted.

How much of the world's evolution has been worked out on the grassy plains and prairies which were the antecedents of our modern ranges and cultivated pastures no one may be able to tell, but if we can make a small inference from the horse, the buffalo, cattle, sheep and other grazing animals we can assign a large place to the meadow environment in the development of some of the most useful of animals. We need only carry back with intelligent imagination the conditions prevailing on the grass-covered plains of our own great West prior to the settlement by the white man to get a fair idea of the probable conditions under which these larger grazing

animals, through the lapse of millions of years, grew into a community of highly specialized grass-eating herbivora. If we come a step nearer and picture the primitive efforts of man to supply himself with more constant stores of food by the domestication of these same grazing animals, we see him as figured in early writings tending his flocks and herds, leading them to fresh pasturage and ever on the alert to secure larger herds and greater range for forage. Until influenced by the stronger desire to hold permanent possession and build more durable habitations, this desire was met by migration, either local or more extended, and even yet we have nomadic tribes representing this primitive pastoral stage in human civilization.

While it may be considered as open to argument, I believe that most of us will agree to the general proposition that the preservation of flocks and herds, that is, the utilization and development of domestic animals, has been a most important and helpful factor in the growth of civilization. Certainly the people whom we associate with the most marked progress in what we are prone to call civilization have been those with which domestic animals have not only served as beasts of burden and sources of food supply and clothing, but also have become more or less the obedient servants, companions and friends of the human master.

Now it needs only mention of the fact that the development of a stock industry or the support of such phases of it as the dairy, beef, pork, mutton, wool and many associated lines, is fundamentally based upon a forage supply which means the need for the greatest possible development and conservation of the meadow and pasture resources.

One reason why the immense place of grass and other forage crops in our system of agriculture is hard to realize is that the more tangible results and available figures appear in other products, and we must look upon the stock industry as a whole with its dependence upon these crops to appreciate the rank it should occupy.

The actual statistics for meadow and pasture crops, while showing an enormous importance, fail to tell the whole truth unless combined in such manner as to get the aggregate not only of hay harvested and sold but also that fed on farms and sold in the form of livestock, and further that consumed by animals in pasture and which does not appear in any figures of harvested crops.

According to figures given in a very illuminating article entitled "A Graphic Summary of American Agriculture" (U. S. Dept. Agr. Yearbook, 1915), there was in the United States in the census year of 1909 a total area of hay and forage crops of 72,280,776 acres, while at the same time there was a total area of "improved land not in crops"—mostly in pasturage or what is termed "improved pasture," of 160,057,000 acres; that is, nearly two and one-half acres of pasture to one of meadow cut for hay. If we add to this the immense areas of unimproved pasture, that is hilly, woodland, and western range land used for grazing, it would give us some startling figures. The census does give us an area of 17,186,522 acres of wild salt and prairie grasses, but this evidently represents only that cut for hay and does not cover areas utilized for grazing only.

The author says, "In the West hay is the dominant crop, contributing 44 per cent of the acreage and 30 per cent of the value of all crops in 1909, and the forage obtained by grazing is probably of almost equal value."

Jardine tells us (U. S. Dept. Agr. Yearbook, 1915), in speaking of the magnitude of the pasture problem west of the Mississippi, "There practically all of the land classed by the census as unimproved, some 250,000,000 acres, or more than 60 per cent of all such land in the United States, is of value for grazing and in use by stock. Of the public lands, some 110,000,000 acres within the National Forests carry livestock, mainly as summer range. Outside the National Forests, practically all the public land, not less than 300,000,000 acres, is used for grazing purposes. All told, then, the problem of improving and maintaining native pastures in the range states extends in a broad sense to something over 660,000,000 acres of land—nearly one and one-half times the area in the United States that is cultivated and cropped."

A similar comparison for the region east of the Mississippi is difficult on account of the mingling of forest, mountain, rocky hill land and swamps, but would certainly show a large area of unimproved land used for grazing purposes.

The article above first quoted says, "In the East grass is of the greatest importance in the hay and pasture province, where in nearly every county hay and pasture occupy 50 per cent or more of the improved land."

This area lying east of the Mississippi and covering a large part of the region north of Tennessee is credited with approximately 16,000,000 acres of hay and forage crops, while the same states would show nearly 50,000,000 at least of improved pastures—about three times as much area as the portion having the crop harvested as hay.

Considerable areas of course exist in the cotton-belt states, with perhaps an even greater proportion of pasturage to hay crop. Whether represented simply in increased pasture products or in the release of large areas of land for production of other food crops the gain in human food supply would be enormous.

If this area as well as the meadow and pasture land could be so managed as to add one-half or possibly to double its product, it is easy to see what a tremendous gain to agriculture would result.

It is in order here to emphasize the distinction between meadows and pastures that form part of a rotation system and those which must for one reason or another remain permanently in a grass or forage crop.

Land which may be open to tillage and which is used for meadow or pasture at intervals is by this very process brought under conditions that favor its fertility and that serves in large measure to determine the control of noxious weeds, insect pests and other inimical factors that prove a permanent drain on the permanent pasture. That is, rotation itself is a most effective control measure. For this reason I wish in this address to deal especially with the problem of permanent pasture. The condition of the permanent pasture as compared with what it ought to be is perhaps most forcibly illustrated by the change which occurs in from three to five years if land which has been cultivated is allowed to remain as pasture or meadow. At some point, perhaps most notably at about the third year, there is a striking drop in the apparent productivity of the field. The pasture is said to have "run out" or to suffer from "soil exhaustion." In reality the land has been occupied by such a dense population of insects and other animals, some feeding directly on the grass and others on this directly dependent mass, that as a matter of necessity there can be little surplus of grass or forage crop to support the farmer's livestock or furnish him a hay crop. In addition, there may occur a host of detrimental weeds, fungi, etc., that must be supported by the soil, the primary crop or some of the

organisms included in the biological complex. The farmer's surplus or dividend is reduced to little or may approach the vanishing point.

The factors which naturally are most familiar to me are biological, and I may seem presumptuous to assume that others have not been studied more fully than these, but from the way the various factors interblend, I am confident that there is much to be learned not only concerning individual agencies but particularly with reference to the interactions and interrelationships of the various agencies.

A little consideration will reveal that the growth of a pasture crop and therefore its ability to support a given aggregate of farm stock depends on the kinds of vegetation present, the physical and chemical conditions of soil, the amount of seasonal distribution of rainfall, the drainage or wash, and the topography, the exposure to sun and wind—and all of these factors may be assumed as open to variation through the season or from year to year and providing a variable complex for any given time. Now if we associate with these the biological elements that combine to make up the ecological status of the field, we have a most intricate complex of agencies, some operating favorably, others unfavorably with reference to the plant growth, but altogether determining the growth that may be counted as available for the pastured stock.

Perhaps the part which needs biological interpretation may best be shown by a brief summary of the various biological elements concerned, and it should be understood that in this summary I do not ignore or underestimate the importance of other factors. The physical agencies of air, water, light, heat, gravity, etc., in all the varied applications to turf-covered soil, as well as the chemical and physical properties of the soil itself, are of fundamental importance in any estimate of pasture possibilities, but my better acquaintance with the biological factors as well as my belief that they have been given less attention than they deserve must be my excuse for devoting my main effort to these factors.

I have in a previous paper read before the Society for the Promotion of Agricultural Science called attention to the problems of meadow ecology with particular relation to the insect population of meadows and pastures. A broader survey to include all the association of living organisms that make up the meadow complex must reveal a still more intricate combination.

The assemblage of plants and animals may be grouped, for instance, with reference to position of habitat, there being a very distinct association among the forms occurring on the plants above the surface of the ground, the large aggregation that occupy the surface debris, the surface of the soil under the debris, the turf or soil just below the surface, and the deeper strata of the soil, some even occupying such depth of subsoil as to be practically untouched by the operations at the surface of the soil. The great mass of organic activity, however, is closely dependent upon conditions of light, temperature, moisture, etc., prevailing near the surface.

To mention some of the more important groups of animals concerned, it may be appropriate to start with the mammals — those forms which may be counted our nearest kin among the lower groups and which have furnished us in various domesticated species the basis for our stock industry. While many of these, and especially the rodents, are counted injurious to the grassland crop, there are many decidedly useful if we consider their influence on the destructive species and many others which have habits so varied in the relation to the primary crop or to the other members of the meadow population that it is practically impossible to assign them positively to one class or the other. The larger carnivores still present, such as wolves, coyotes, badgers, skunks, etc., which may range into grazing or meadow lands, may of course be counted useful so long as their main attacks are made upon rabbits, field mice, insects or other destructive forms, but very often they may prey upon useful forms and thus complicate their economic status.

The rodents generally, so far as grasslands go, may be counted injurious, since as vegetable feeders they serve to reduce the crop. Rabbits, field mice, gophers, and for the most part probably the prairie ground squirrels or spermophiles, may be placed in the noxious group. For the latter forms, however, there seems to be, especially for the meadow and pasture inhabitants, distinct allowance for the fact that at times they are voracious feeders upon destructive insects such as grasshoppers, cutworms, sod worms, etc. This has been noted especially for the 13-lined spermophile (*Spermophilus* 13-*lineatus*), which occurs in great abundance in the prairie regions of the northern Mississippi Valley.

I understand that the United States Biological Survey and state agencies have been conducting a great campaign against the spermo-

philes of the Northwest, especially in the plain region of the Dakotas, and with what is apparently a great gain for the forage value of the ranges. Without questioning the immediate returns secured or the imperative need of action, I venture to suggest that careful attention to the later results, especially if the members are permanently reduced, in order to make sure that this does not permit the increase of other injurious organisms. If not already established, it should also be determined whether the species attacked have, like the related 13-*lineatus,* any insectivorous habits.

The field mice have, I take it, fully earned their reputation as destructive forms not only as directly injurious in the grassland but also from their incursions into adjacent orchards and shrubbery plantations. Any agency reducing their numbers would be useful.

The shrews and moles, while sometimes troublesome in lawns, gardens, golf grounds, etc., must on account of their general predaceous habits be ranked as useful checks on destructive forms, especially for permanent meadows and pastures.

Shull has shown that while very inconspicuous and largely ignored, the short-tailed shrew occurs in great numbers in practically all kinds of fields and throughout a very wide range covering our meadow and pasture territory. It has a wide range of food, including snails, insect larvæ, crustaceans, earth-worms, etc., but its economic value is especially manifest in its diet of meadow mice, white-grubs, cutworms, wire worms, etc. Certainly no policy of pasture treatment should ignore these creatures so long as the destructive forms are present, and if absent the moles may be expected to migrate to more favorable feeding grounds.

Birds occupy a most important relation to the pasture, and in many connections. Aside from many species that nest within the area of the grassland and rear their nestlings on the food collected, there are many that live and nest in adjacent fence rows, thickets or woodland and depend on continued forage into the open field for food supplies for themselves and their young.

Hawks and owls secure the smaller mammals, birds, reptiles, insects, etc. Hosts of insectivorous forms serve to reduce the insect population, while other hosts of seed-eating forms may affect the weed population or the primary crop itself.

Snakes and other reptiles must be recognized as taking their toll from among the other organisms, and frogs and toads in many localities occupy a place of large importance.

If I should enter on the multitude of insects I would certainly run the risk of wearying you before a start had been made upon the list which I am sure runs into thousands of species. It may be sufficient to say that they occupy every phase of relation to the crop, hosts of them attacking the crop directly and others dependent on those primarily destructive for their survival. Particularly intricate and complex are the relations of those forms which as parasitic or predaceous species enter into the endless chain of action and reaction between inimical or useful forms, or such groups as ants, bees and wasps, which by their attacks on other forms or by their service to the plant in pollination or to other organisms in their means of reaching necessary sources of food, carry on a most complex relationship in the general association.

Spiders of many kinds and in bewildering associations with other organisms play their part, and ticks, mites and ever certain crustaceans must be admitted to this complex biological community.

Earthworms are so familiar that no doubt all attentive observers will admit their place, and the classic work of Darwin has shown their varied influences. Still I doubt if we have yet any adequate conception of the role they play in soil fertility or crop production. We know they occur by millions in practically every field, at least in all fairly humid regions. We can appreciate that they must serve in a striking way to determine the physical condition of the soil, but to what extent they may influence the chemical or biological conditions or the limitations for certain plant growth we have, I believe, an immense amount to learn. Furthermore, these humble worms serve as a food supply for numerous other animals, including moles, birds, etc., and in addition carry with them a most astonishing assemblage of internal parasites of different groups of animals, some of them connected by alternation of host with animals of other groups and possibly of direct importance to the livestock for which we aim to devote the product of the land. Such associations, of course, occur in many others of the grassland population. I cannot take time to detail them here, and indeed much of this may seem to be elementary biology. Its direct bearing on our problem, however, must excuse its presentation here.

The forms so far mentioned are mainly of such size that they may be noted by the casual observer. I count it unnecessary to remind you of the enormous invisible host of lesser organisms that can be

revealed only by microscopic study. The whole branch of microbiology, a large section of which relates to the pasture crop, is sufficient proof of their place in the scientific study of this problem. While grouped for technical study on the basis of their size, biologically they represent a host of different divisions among both plants and animals. The Nematodes, though not all strictly microscopic, are best appreciated as miscroscopic forms and the free forms occurring in the soil and of much greater abundance than commonly supposed are overlooked because of their minuteness. Many of these worms bear extremely important relation to domestic animals as parasites, some stage of which must be spent on the grass or in the soil or in the form of alternating parasites in the bodies of various other inhabitants of the ground.

Flukes and tape-worms of many kinds and with most intricate migrations and alternations among the other organisms in an obligatory association have certainly a great importance and one which has been quite generally acknowledged. Nevertheless, the ecologic association upon which their survival is so absolutely dependent has been determined for only a few of the species that are known to be of economic importance. Then we have the large group of strictly microscopic forms included in the Protozoa. These at first thought seem to have little place in the pasture ecology, but in one way or another, perhaps most largely as members of the parasitic colony thriving in the tissues of other animals, they constitute an enormous though invisible part of the organic assemblage. They must inevitably bear a most important relationship in the economic complex.

Naturally associated with the Protozoa are the hosts of bacterial forms which either upon the plant or animal basis or the organic debris maintain an existence and perform a function in the transformation of organic matter which may be of most essential service or serious damage according as they affect the useful or the inimical factors in the association. Soil bacteriology has, I suspect, like other biological phases, only begun upon the problems which must be solved if we are to have a scientific basis for intelligent development of our pasturage resources.

The parasitic fungi, the rusts, and blights and molds also present their quota of pressing problems, and the hosts of higher plants that invade the grasslands and as "weeds" occupy the space or exhaust the supplies of plant-food that should go to the primary crop, must perforce be recognized.

It is certainly unnecessary in this assembly to go into further detail concerning the multitude of organisms and hence the magnitude of the problems involved in this association.

If I have succeeded in indicating the great variety of forms, both plant and animal, that enter into this organic complex, it is evident that we have here not only thousands of different kinds of organisms but millions on millions of individuals in most intricate relations of interdependence and interaction. I think it will also be evident that no study of any one of the elements by itself can give conclusive results as to its economic status. The agencies for investigation of this complex must be associated in some manner commensurate with the intricacy of the association studied.

It appears that while we have made considerable progress in the study of individual phases of the pasture problem there has been so far little progress in the correlation of the results or of interpretation of the facts acquired in the terms of the combination as a whole. Experiments upon the use of fertilizers or the effect of varied practices in grazing have given "conclusions" with apparently a total disregard of the fact that the pasture used was supporting an enormous population aside from the domestic animals used in the experiment. This omission must certainly invalidate any conclusion in comparison with another tract the biologic content of which is in all probability very different. In any case a disregard of the biologic content must introduce a source of error of unknown magnitude. How great this source of error may be is perhaps suggested if we compare the insect population of pastures of different age or of different topography. Even with extreme care in selecting tracts of identical history and similar character the local variation in biologic elements may be a source of uncertainty that ought to be recognized.

Still another phase of the subject is presented by the fact that the permanent pasture furnishes a perennial reservoir for a number of the most troublesome pests of other farm crops and especially corn, wheat and oats.

The problem also involves factors of cooperation or community effort to make improvements effective, possibly in many cases even legislation to ensure protection of those who follow methods of control from the neglect of community members who fail to do their part; possibly also for the exclusion or restriction of foreign or newly introduced species that menace the pasture crop.

It is not intended here to enter upon the questions of possible measure for direct improvement of pasture, but simply to indicate some of the open problems the solution of which appears to be necessary to any scientific development of control measures on such a basis as to affect the permanent status of pasturage.

It is recognized that we have some distinct contributions from many of the individual phases of the subject, as well as long established practices based on the general experience of past generations. In many cases, however, these may be found contradictory in nature or unsupported by scientific experiment. Tests of fertilizers without regard to their influence on the biologic content must be inadequate, and experiments in the control of insect pests without consideration of soil, topography, drainage, etc., must give only partial conclusions. The relation of fertilizers or of drainage or flooding or drouth to the animal or plant population subsisting on a given field would seem a promising field of study.

The possibilities in alternate light and heavy grazing or other variations in the usual routine of cropping the field and any methods of mechanical treatment of possible influence may offer some fruitful fields of experiment. So, too, there may be a field worth entering in experiments with some of the toxic gases developed for war purposes. Possibly all of these might be prohibitive in cost for practical use, but experiments with them might give very valuable information as to the productive possibilities of a field freed from the drain of its dependent population. It is conceivable that we might learn some very interesting facts as to results of such toxic gases on the less migratory animals by a prompt survey of the gas-soaked areas in the battlefields of France and Belgium.

But, as already stated, it is not my purpose to outline specific subjects for experiment or investigation. I desire rather to concentrate attention on the general aspects of the problem and the interblending factors that should be recognized in any experimental work that is undertaken.

It seems therefore, from the magnitude of the interests involved and from the many factors concerned that this problem of permanent pasturage merits the attention of some broad organization and that it should be so organized as to secure the cooperation of technically trained men in the various scientific branches concerned. Since the proper investigation and solution cannot be expected by

isolated effort some agency for associated action must be secured.

A committee or commission made up of expert representatives for soil chemistry, physics, meteorology, agronomy, botany, bacteriology, ecology, zoology and entomology and possibly more specialized divisions of plant pathology and animal parasitology, working together and supplying the material and technical knowledge required for comprehensive study of the problem as a whole and for the entire pasture or grazing section of the country, would certainly secure more important results and in much less time and with far less expense than can ever be hoped for in the disjointed and fragmentary studies on different phases of the problem, even if taken up by many different workers and in many different states.

Whether such a committee or commission should be formed within the United States Department of Agriculture; by joint action of a number of experiment stations; through the National Research Council, or in some other manner, seems much less important than that it should be undertaken on such cooperative basis and with such scope and support as to provide comprehensive and exhaustive work with prospect of far-reaching and widespread benefit.

Since our society embraces a wide diversity of interests in agricultural science and could serve as a medium for the inauguration of such a plan, it may not be out of place to suggest that a committee be appointed to look into the matter; formulate, if deemed proper, some plan of procedure; and present a general plan to the body which seems most appropriately open to the organization of a working commission or such other technical body as seems necessary to accomplish the purpose.

More Study of Pastures and Pasturing Needed

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The great war in which the principal nations of the earth have been engaged has forcibly called to the attention of food producers many important problems. The problems connected with the producing of sufficient food for the armies and nations of the world are very complicated. The production of some products is competitive to that of other products. For example, the production of grain is somewhat opposed to the production of animal products. Land which is used for producing corn and wheat may also be used for producing livestock. While there is much land producing grains which might also furnish pasturage, there is a great deal of land not well adapted for grains that is quite suitable for pastures, and which is not producing to full capacity. It is also true that much good grain land which is being used for pastures does not produce all it is capable of doing. Two acres of pastures to maintain an animal unit during the pasturing season is much below the corresponding capacity for grain production.

Since animal products are an important part of our food and fibre supply, it is desirable that we give attention to whatever may assist in increasing this supply. Even after the war, the demand for animal products will continue to increase. Beef, butter, milk, pork, mutton, wool, poultry and eggs have all been increasing in price for a number of years, and even before the war broke out there was no indication of the lowering of the price of these commodities. Apparently the demand for these commodities was being created faster than the supply. In a country as large as ours and with the comparatively low land values it seems that these animal products are most largely and most economically produced when the livestock is grown on pastures.

Inasmuch as pasturage is so important in livestock farming it is rather strange that so little has been done in an experimental way with pastures and pasturing. The publications of our experiment stations have very little or nothing to say about tame pastures, es-

pecially permanent pastures and pastures of the grasses. Apparently we have so recently come from a condition of abundant areas, unbroken prairie pastures, and large areas of woodland pastures, and other non-cultivated land that we have not fully realized the importance of replacing these virgin conditions by artificial conditions. The instances in which farmers have seeded down cultivatable land to permanent pastures are exceedingly few. In most cases farmers feel that they are not justified in converting land capable of producing grain and hay into permanent pastures. While the profitableness of converting high-priced land into permanent pastures may be a debatable question, there seems to be little room for debate in the case of cheap land and land which is too rough for successful cultivation.

A survey of the situation shows that we are not able to answer with definiteness many of the questions with which we are now being confronted. Many farmers and land owners are interested in permanent as well as temporary pastures. They are inquiring about the adaptation of plant species and their values for animal growth and animal products. They are inquiring about the time, method, rates of sowing of pasture plants, and likewise about the number of animals that may be pastured on a given area, and many other questions which we are not able to answer very satisfactorily. In view of this it is proposed that more study be given by our investigators to the problems arising out of the situation, and among these the following are suggested for consideration:

1. Relation of soil conditions and plant species. It is obvious that some species of grasses are better adapted to some conditions than to others.

2. Seed-bed preparation. Most grass seed is sown without any special preparation of the seed-bed, and yet the man who is preparing a lawn uses great care in having his seed-bed in the very best condition to receive the seed in order that there may be an even stand as well as a luxuriant growth. We do not know whether it will pay to give careful preparation to a field for the purpose of sowing grass.

3. We have not determined experimentally the merits of single species as compared with a mixture of two or more species.

4. We have not worked experimentally with grasses alone, or with grasses and legumes in combination, nor have we determined

what species go together and supplement each other to the best advantage.

5. Not much experimental knowledge exists as to the proper fertilization of grassland, as to the time of fertilizing, rate and method of application, or the kind of fertilizer that is most economical.

6. Likewise, we have not determined the best time to sow, the rate of seeding, and methods of seeding—whether it is best to seed with a nurse crop, or alone; to cover the seed, or let it lie on the surface.

7. The carrying power of pastures has not been subject to much experimental attention. We ought to know the effect of pasturing lightly, continually, as compared with pasturing heavily, intermittently, that is for a week or two at a time with a chance to recover for a week or two.

8. Again, we ought to know the effect on the next year's growth of late fall pasturing. It is a common practice to pasture heavily in the fall, simply because the pasture is good, without regard to the probable effect on next year's production.

9. We have pretty well worked out the meat and milk-producing power of the various grains, but we know little or nothing of the comparative feeding value of the different grasses, and little more about that of the legumes.

10. Even though a farmer has decided to sow a permanent pasture, when there is recommended to him the quality and mixtures which from our meager knowledge we believe to be best, he is loath to make the expenditure for seed because of the high price. This suggests that there should be some stimulation of the quantity and quality of seed production. The production of grass seeds is not a business that is occupying the attention of many men in this country. The low germinating quality of grass seeds suggests that it might be possible to improve the quality of the seed sold.

11. This leads us to say that selection and breeding experiments with grasses are practically unknown, and yet it must be that this field is a rich one for the investigator.

With our knowledge of pastures and pasturing enlarged, we could increase our production of livestock and animal products economically and at the same time have as much (or more) land available for the production of grains as we now have.

Some Soil Studies

W. P. Headden

Colorado Agricultural Experiment Station

At a meeting of this society held in Portland, Oregon, in 1909, I had the pleasure of presenting an account of the occurrence of remarkable quantities of nitrates in some of our Colorado soils. The subject at that time was an entirely new one, so new in fact that credence was given with the modest conservatism sometimes found in a scientific society. I wish to present today some of the results obtained in the prosecution of that subject and show, if I can, its very great importance in the agriculture of the semi-arid West.

When I later announced the occurrence of unusual quantities of nitrates in restricted areas in many widely separated localities in Colorado, the announcement was received with open doubt, which caused no surprise, for no one had previously described such, except a few occurrences in caves, the salt-petre earth of India, and a few occurrences associated with refuse. For this reason it became incumbent upon me to establish the fact by the description of a large number of occurrences in different parts of the state, under different local geological conditions, to demonstrate beyond any doubt that these occurrences had a real agricultural significance and did not belong to the class of curiosities, with no other significance than a challenge to our ingenuity to account for them. Accordingly, I have described a great many instances of such occurrences in Colorado in which these nitrate-spots have carried from 0.1 to 5.6 per cent of nitrates calculated on the basis of air-dry soil or earth. I recently analyzed a sample gathered from the surface of such a spot which carried nitric nitrogen corresponding to 14.14 per cent of sodium nitrate. These occurrences are not confined to Colorado. I have seen such in California, Idaho, Oregon and Montana, and have received samples of such soils from New Mexico, California, Idaho and Montana. I also have samples of earth containing large quantities of nitrates from Oregon, which occurrences would scarcely be classed with those in the soils of our cultivated areas and which I do not intend to discuss at this time.

In one of our earliest publications I stated my conviction that these spots were only exaggerated instances of a general condition existing in our soils. I was forced to this conviction by the fact that I had found these spots in all of the cultivated sections of the state that I had examined.

The seriousness of this occurrence of nitrates was apparent from the first ascertainment of this as a fact, for excessive quantities of nitrates exterminate vegetation. A common complaint has been and continues to be that the land has become so unproductive that nothing will grow on it. The record, as we have observed it, is a sad one. Not only has orchard after orchard been killed, but many acres of land have become partially or wholly unproductive. The spots have grown from a few square feet to acres in area and are now prevalent in sections where 5 years ago they were unknown. In a few cases they have temporarily, at least, disappeared; whether they will return again remains to be seen, but I see no reason why they may not.

THE SUGAR BEET

I have stated my conviction that these spots present only exaggerated expressions of a generally prevailing condition and the reason so far given is the general distribution of these spots. There are stronger but less evident reasons for this statement; by less evident in this connection I do not mean less forceful, but not apparent to the eye. These spots proclaim by their barrenness, their color, and their physical condition that they are wholly unlike ordinary soil. The more forceful testimony to the prevalence of this condition is of an entirely different character—I refer to the quality of the crops produced in large sections of the state. In this connection we studied the sugar beet, but the subject was approached from the other side, i. e., to ascertain why the sugar beets had deteriorated rather than to prove that the general distribution of the nitrates had suppressed the good qualities of the beets produced. This study was taken up for the Arkansas Valley. The general characters of these beets soon led us to infer that they were overfed with nitrates.

In this connection I will state the salient facts in the case. Prior to 1904 or 1905 the average sugar content of beets grown in the valley was about 17.5 per cent. The Experiment Station began growing beets in the valley about 1892 and our records show that

the beets grown averaged as just stated. The first campaign of the factory of the American Beet Sugar Company at Rocky Ford was made, I think, in 1900, and the average sugar content of the beets treated during the first 3 years was about 17.75 per cent. This average had fallen by 1909 to 14.2 per cent and in 1917 it was, according to my information, scarcely 13.5 per cent. In 1909 the president of the Holly Beet Sugar Company made this statement: "A few years ago when we were raising beets they averaged 18.0 per cent of sugar; now when we have a factory 14 to 15 per cent beets are extra. Some of our beets are very poor, 12.0 per cent or lower, and they won't keep." These are as nearly as I can recall his exact words.

I do not know what the total tonnage of the valley was at that time, but there were 5 factories in operation. I think that only 2 factories have operated for several years past.

The task that I assigned to myself was to find out the cause of this deterioration. An examination of the beets proved the presence of nitrates in the roots in easily detected quantities, and it scarcely need be stated that their presence was easily established in the molasses and in the Steffens waste waters.

The characteristics of the beets were well marked. They were immature, the flesh was white and watery, the sugar content and apparent coefficient of purity was low, the beets kept poorly and caused trouble in the factory. These facts with the presence of nitrates in the beets pointed directly to an over-supply of nitrates in the soil, but fell far short of establishing this. Two things at least were absolutely required to establish it to the satisfaction of any candid person. First, to prove that the nitrates were actually widely distributed in larger quantities than usual; second, that beets grown with an excess of nitrates actually possess the characteristic properties shown by these beets.

The first of these problems made it necessary for us to ascertain what amount of nitric nitrogen is usually found in good cultivated soils. I could find no answer to this question in any of the authorities at my disposal. The most satisfactory data that I found were ascertained by Lawes and Gilbert in their studies of the Rothamsted soils. According to these authors 8 parts per million in the surface portions of the soil is about the maximum to be expected. We endeavored to ascertain the amount that usually occurs in our ordi-

nary soils cropped to wheat and oats. We found that such soils contained from 1 to 8 parts per million, but mostly from 2 to 5 parts per million, for the top 2 inches of cropped soils. This amount decreases so rapidly that at a depth greater than 12 inches we usually find less that 1 part per million. These are the results of studies made on cropped soils at Fort Collins where the conditions are as typical of good soil conditions as can probably be found anywhere. We believe that we assume a very liberal upper limit for the nitric nitrogen in ordinary soils when we set it at 8 parts per million. It is necessary to assume some superior limit, for we shall see that a very few parts per million of nitric nitrogen in some cases suffice to determine the character of the product grown. I am very much clearer on this point now than when this work was done and have grown more fully convinced with more extended observations that the data here given present the facts very nearly.

In an endeavor to ascertain the actual quantities of nitric nitrogen present in the soils of the Arkansas Valley in which these beets already referred to were grown, I obtained 110 samples of soil taken from 64 fields. These samples were taken to the depth of 6 inches, deep enough to avoid maximal quantities in individual samples. We found that one-third of the 110 samples contained 10 or more parts per million up to 160 parts per million. The greater part of these samples were taken in October immediately after the beets had been harvested.

The significance of these figures becomes more apparent when we change these strictly analytical data into commercial terms. One part of nitric nitrogen is equivalent to a little more than 6 parts of sodium nitrate and 100 parts per million of nitric nitrogen is equivalent to 600 pounds of sodium nitrate to the million pounds of soil, or approximately 1200 pounds in the top 6 inches of soil. The sample that contained 160 parts per million of nitric nitrogen contained 1920 pounds per acre in the top 6 inches, the depth to which the sample was taken. These samples were taken immediately after harvest and from soil that had been cropped that season.

I have introduced these data to show how we endeavored to answer the first problem presented to us, i. e., the general occurrence of unusual quantities of nitrates in the soils of the Arkansas Valley.

The second thing that we considered necessary to demonstrate, before we could claim that a solution to the problem had been given, was to show that the characteristics of these beets can be produced by the application of nitrates. This we did by means of an extended series of experiments and observations. Our experiments were carried out on land that had been planted to beets the preceding year. Our object was to find out what are the specific effects of excessive quantities of nitrates upon the composition and character of the sugar beet, or more specifically to determine whether nitrates produce the kind of beets that were then being delivered to the factories. We found that on the land on which our experiments were conducted the application of 250 pounds of sodium nitrate, or 40 pounds of nitric nitrogen per acre, equivalent to 10 parts per million calculated on the surface foot of soil, increased the crop and improved the quality of the beets, but that 500 pounds of sodium nitrate equivalent to 20 parts per million, calculated likewise on the acre-foot of soil, depressed the sugar content and quality of the beet. We found that each increment by which we increased the nitric nitrogen caused an increased depression in the sugar content and working qualities of the beets. The increment adopted was 10 parts per million calculated on the surface-foot of soil. When we increased the nitric nitrogen by 40 parts per million we depressed the sugar from 15.4 per cent to 11.9 per cent and produced beets with the poor shape and objectionable characteristics of the average beets produced in the valley.

A detailed analytical study of these beets established beyond any question that the bad qualities of the beets then produced in the Arkansas Valley were identical with the properties imparted to beets by an excess of nitrates.

The investigation, made in cooperation with the management of the American Beet Sugar Company, was carried further. The beets were worked in an experimental plant to the production of thick juices. The results of this work confirmed in the fullest possible manner the conclusions arrived at by purely analytical methods.

It became important in this connection to ascertain whether it is really a fact that as much as 40 parts per million of nitric nitrogen is formed in our soils in the course of a season. In order to determine this, Mr. Zitkowski, chemist to the American Beet Sugar Company, selected two fields, divided each of them into 7 sections and

took 7 series of samples to the depth of 1 foot from each section between March 4 and August 25. Two very different pieces of ground were purposely chosen and planted to the same variety of beets. The maximum amount of nitric nitrogen found in Field A on March 4 was 10.8 parts per million; by June 30 it had risen in all sections, ranging from 12 to 36 parts per million. By August 25 the maximum found in any section was 12 parts per million. The beets produced on this field were excellent; the samples ran very evenly, between 16 and 17 per cent of sugar. The same data for Field B were very different. On March 4 the maximum for the nitric nitrogen was 20.5 parts per million; by the second of June 5 out of the 7 sections showed a marked increase, carrying from 32 to 112 parts per million; on June 20 the minimum found was 15 parts per million, the maximum 136; on August 25 the minimum found was 47 and the maximum 333 parts per million. The beets from this field were poor; the average content of sugar was 12.6 per cent.

In solving these questions we furnished very strong proof that there is a general condition prevailing in our soils under which unusual amounts of nitrogen may exist in the form of nitrates, and incidentally that the supplying of 40 parts per million during the growing season is sufficient to cause the beets to be inferior in shape, in yield, in percentage of sugar and in working qualities; further, that the amounts of nitric nitrogen formed during the season is, in some soils at least, very much in excess of the 40 parts per million that we added.

We have presented succinctly the following facts as shown by our study of the beet crop in the Arkansas Valley: first, the occurrence of unusual quantities of nitrates in these cultivated soils; and second, that in large sections there are enough nitrates present to produce the characteristic physical properties as well as the peculiarities of chemical composition which are produced in beets grown on the best soils by the application of an excess of sodium nitrate.

In the case of the beet crop these injurious effects were produced by 80 parts per million of nitric nitrogen calculated on an acre-foot of soil and the maximum injurious effects were produced by 120 parts per million. Further, the soil of a field planted to beets and systematically sampled to a depth of 1 foot from March 4 to August 25 showed a maximum of 333 parts per million of nitric nitrogen.

Also we have shown that samples of soil taken to a depth of 6 inches after the beets had been harvested contained as much as 160 parts per million of nitric nitrogen. These quantities are greatly in excess of those which produce maximum deleterious effects upon the character and properties of the sugar beet.

WHEAT

The statement has been current for many years that our Colorado wheat does not yield a first-class bread-making flour and that hard wheats imported into the state as seed yield soft wheats which produced only good biscuit flour. Our study of this subject led us directly to the question of the nitrogen supply in the form of nitrates. The character of our wheat is no more uniform than the quality of our beets. Some of it is as fine, hard wheat as can be produced anywhere and some of it is soft and objectional, while a great deal of it is mixed. We attempted to ascertain the cause of these differences. We were exceedingly fortunate in the choice of our initial experiments, for we succeeded in producing the extremes of quality on plots of similar soil lying side by side, during the same season and under identical treatment, except in respect to the mineral fertilizer added. We found in this case that nitric nitrogen in the form of sodium nitrate produced hard wheat; this was the case on 9 plots with 3 different varieties of wheat, while the other 27 plots produced either soft wheat or mixed wheat. These experiments were repeated many times with uniform results.

Field observations showed that some land produced small-grained, hard wheat, while other lands yielded large-grained, plump, soft wheat, even when the fields had been planted with seed from the same lot and were in the same locality.

These facts remove completely the vexed questions of climatic conditions, heredity and incidental diseases, and reduce the problem to a question of the supply of nitric nitrogen. This question was taken up at Fort Collins, where our soil conditions are different from those of the Arkansas Valley, and we had to study this question anew.

One of the first striking facts that presented itself was that wheat grown after fallow cultivation had the characteristics of wheat grown with the application of sodium nitrate, whereas wheat grown after wheat, oats or barley had the characteristics of our ordinary

crops of mixed wheat. I do not intend at this time to discuss the wheat, but only the causes of these differences which, as already stated, is a question of the supply of nitric nitrogen as indicated by the results of our experiments. The composition and characteristics of the wheat grown on land which had been cultivated fallow raised the question of the nitrogen supply and its transformation into nitric acid and nitrates, respectively, in this soil as affected by the fallow.

We did a very large amount of work on this subject which cannot be given in detail on this occasion and I have no desire to give any large number of analytical results, for I do not believe them necessary. The facts given in regard to identity in the character of the wheats produced on fallowed ground and with the application of nitrates on cropped ground were strongly suggestive of our experiences with the beet crop. In this case an improvement in the quality is effected, but the results of the application of nitrates were in the main detrimental to the yield, the same result that was obtained in the cases of the beets in which excessive quantities were applied.

Here we again meet the question, What is an excessive quantity of nitrogen in this form, viz., as nitrates? I can answer this question only within a certain limit, but this answer is most positive and shows how closely our conditions border onto the optimal. The application of 40 pounds of nitrogen, or 10 parts per million calculated on the surface-foot, applied at the time of planting, is a sufficient quantity to change radically the growth of the plant and the composition and the characteristics of the wheat. In some cases this quantity of nitric nitrogen sufficed to injure the crop very seriously, reducing its volume and causing shrunken wheat. The quality, however, was uniformly improved. We made in all about 90 experiments, in which we applied various amounts of nitrogen as nitrate of soda. Forty-five of these were in every way according to rule and belonged to regular series. In no single instance have we obtained a remunerative increase in yield and in only a few cases have we had any increase at all; on the contrary, we usually had inferior yields.

The results observed on the fallowed ground suggest that the amount of nitric nitrogen present at the time of planting (the wheat was of a spring variety) was sufficient to produce all of the good effects of a direct application of sodium nitrate. This amount must have survived all of the changes taking place in the soil, both chemi-

cal and mechanical, during the preceding year up to the time of planting.

We endeavored to ascertain by direct determinations whether such quantities of nitrates were actually formed in this soil. The results as expressed in the composition and properties of the wheat produced are strong, but scarcely constitute sufficient evidence to justify the assertion that this formation of nitrates actually takes place. With this end in view we sampled a fallowed section in November and again in December, taking 3 series of samples at each sampling, each individual sample being composed of 3 subsamples. The samples representing the soil from the fourth to the seventh inch, inclusive, contained in November, 21, 22 and 28 parts per million; the same section in December showed 18, 25 and 31 parts per million. The most nearly comparable data that I have for cropped land show for November, 2, 3.4 and 3.5 parts per million, and in December, 3.8, 3.8 and 5.0 parts per million. These results show clearly that there is a material accumulation of nitric nitrogen during a fallow, and the amount present on December 4 in this case was two or three times as much as was necessary, when applied at planting time, to change the growth and character of the wheat entirely, even to do injury to the crop. It cannot surprise anyone in view of these facts when we state that we have seen many instances in which this accumulation of nitrates has taken place to such an extent as to destroy crops. This effect is, in fact, the one that is most often noticed and accounts for the complaint of spots on which nothing will grow. This complaint may vary a little in different cases but has remained pretty uniform for the past 12 years.

The destructive effects of these accumulations have been serious. Orchards, especially apple and cherry orchards, have suffered very greatly because these were kept in clean cultivation for many years. These form, perhaps, the most striking cases of injury from this cause, but it is only because dead trees or dying ones are more efficient witnesses to bad conditions than fallow land. I have seen many square miles of land which had very largely passed into a condition of non-productiveness. An examination of such land shows, in many sections, the presence of prejudicial quantities of nitric nitrogen. Nitrates are not always the cause of a non-productive condition of soils, but they are in very many cases in the semiarid West.

A question which undoubtedly has suggested itself in the presentation so far made is, What is the usual ratio of nitric nitrogen to the total nitrogen in soils? I have sought an answer to this question in our agricultural literature and have found almost nothing on the subject. As nearly as I have been able to find out the nitric nitrogen usually constitutes less than or about 5.0 per cent of the total or for ordinary soils from 5 to 8 parts per million, which agrees with our previous statement pertaining to this subject.

In many instances this ratio in these nitre-spots is exceedingly high, even up to 90 per cent. It is so high and the quantity of nitrates present so large that they present difficulties in any explanation that may be offered to account for their presence.

In the case of the wheat we found that the addition of 10 parts per million, calculated on the acre-foot (in this case we have the top foot in mind), to soil that contained in May approximately 5 parts per million, sufficed to determine the growth of the plant and of the character of the wheat produced. Further, it has been found that the addition of 20 or 30 parts per million of nitric nitrogen shows an increased effect upon the wheat crop, but it is not very much more than that produced by 10 parts per million which, applied to our soil, is already an excessive amount.

We have stated that cultivation of the fallow land produced the same effect as the direct application of sodium nitrate. Of this the nitrogen content of the wheat produced is a good measure. This assertion is borne out by the results of many analyses. The nitrogen content of a sample of Red Fife grown on fallowed land was 3.008 per cent, of one grown on land which had been cropped the previous year and dressed with 120 pounds of nitric nitrogen to the acre, it was 2.666 per cent, of one grown on unfertilized, cropped land, separated from the fallowed land by a 16-foot space, it was 2.227 per cent.

The ratio of nitric nitrogen to the total nitrogen has been mentioned as of unusual importance. It is often very high. We have found it as high as 17 to 20 per cent in cropped land and very much higher in the nitre-spots.

It would be wholly unnecessary to be insistent upon the injurious action of an excessive amount of nitrates in the soil if this were our object, but it is not. Our object has been to show that there is an excess of nitrates formed in our soils because of inferiorities ob-

served in the character of the crops produced. This was most strongly marked in the character of the beets produced in the Arkansas Valley. The wheat crops studied at Fort Collins yield us excellent criteria whereby to judge of these effects, but the results obtained are not all in one direction as in the case of beets. In the case of the wheat we enhanced the quality but almost uniformly depressed the yield, and produced big but weak plants.

The results obtained on fallowed land taken in conjunction with those produced by the application of sodium nitrate point conclusively to the accumulation of nitrates during the fallow. This may be an accepted and a well known fact. It is not, however, definitely stated to my knowledge, nor is the extent to which the nitrates are removed from the soil by a crop of oats, barley or wheat stated. For my present purpose it does not matter at all whether the plants have used up the nitric nitrogen or prohibited its formation; it is a fact that the nitric nitrogen in such soils is reduced to very small amounts, often to 1 part per million, even when the samples are taken to only a depth of 2 inches, within which depth we almost always find the largest amounts of it.

In order to answer the questions suggested by these facts we studied the development of the nitrates in cropped soil from the time of harvest until the following March, taking the samples to a total depth of 4 feet. There was an increase which is best shown in one of our plots planted to Kubanka wheat. On August 3, 1915, at the time of harvest, the surface foot of soil contained nitric nitrogen equivalent to 12.3 pounds of sodium nitrate, the same section on December 14, 1915, sampled in the same manner, carried nitric nitrogen equivalent to 104.1 pounds of sodium nitrate; another plot, planted to Red Fife, increased from 29.3 pounds to 103.1 pounds. The rate of the restoration of the nitrates in this soil is sufficient to furnish a considerable supply of nitrates, provided they are not washed out or destroyed within the soil.

The question regarding the fluctuations in the amounts of total nitrogen present in the soil, especially the surface portions of it, are still more difficult to ascertain than are those in the nitric nitrogen, as it is only with the greatest difficulty that a truly representative sample can be obtained. In order to find out to what extent we could rely upon samples taken in the field, we took 150 samples to a depth of 1 foot from an area 5 x 30 feet, or a sample from the mid-

dle of each square foot. The total nitrogen was determined in duplicate and when a difference of more than 3 in the fourth decimal place occurred the determination was repeated. The result of this investigation went to show that it is wholly inadmissible to depend upon samples collected with a tube or otherwise to show the fluctuations in the amount of total nitrogen in a plot of land for the purposes here in view, for the variations from foot to foot may be greater than those occurring in any given place and greater than variations which may be of great significance when measured in the character of the crop grown. In order to avoid this difficulty and to ascertain the changes in the amount of both the total and nitric nitrogen in this soil as nearly under field conditions as possible, we took 3000 pounds of this soil, mixed it by shovelling over several times and then by passing it through a screen five times. It was shovelled over twice more before it was finally made into a bed and sampled. Observations were made on the amounts of nitric and total nitrogen in this mass of soil for 40 days. We kept the moisture in the mass at 15 to 17 per cent by addition of ammonia-free water. The soil was in the open but protected by a wire fence from the approach of animals and arrangement made to protect it from rain. This soil was sampled at intervals of 3 and 4 days, 13 sets of samples in all being taken. Our final results showed that this soil had gained during the period of observation—40 days—36 parts per million of total nitrogen and 15.79 parts per million of nitric nitrogen. The determinations of total nitrogen were made in quadruplicate and those of the nitric nitrogen in duplicate. There were variations in the amount of total nitrogen present from period to period, but it was lower at the beginning of the experiment than at any other time. This is not true of the nitric nitrogen, which at one time fell off sharply to less than one-half of that present at the beginning, but this was followed by a rapid increase. The increase in both forms of nitrogen took place more rapidly in the second than in the first three inches.

Heretofore we have emphasized the presence of nitric nitrogen, its increase in the soil and its ratio to the total nitrogen, but have left it as an open question whether or not the total nitrogen was subject to similar variations. The last experiment was made with as much care and as nearly under field conditions as possible to demonstrate this fact, and to obtain the measure in which the total

nitrogen itself may vary. In the 40 days that this experiment was continued we see that the increase in total nitrogen corresponds to 917 pounds of proteid matter (N $\times$ 6.25). In other words, the fixation in this soil had added this much nitrogen in the form of proteids. Nitrification does not add to the store of nitrogen but simply changes the nitrogen present into this form. The intermediate step of ammonification has been proved by Dr. Sackett to proceed with great vigor in our soils.

The question again comes up in regard to the correctness of my view that the nitre-spots are only exaggerated instances of characteristic properties of our soils, i. e., the possession of a power to fix atmospheric nitrogen, converting it into proteid nitrogen by the agency of its bacterial flora, the *Azotobacter*, and subsequently into nitrates. Laboratory experiments entirely independent of the experiment previously given, but conducted with this soil, gave much higher results than those obtained in our imitation of field experiments. These experiments gave a maximum fixation of 124.3 parts per million in 48 days. This was the soil itself as taken from the field and not a cultural medium inoculated with a suspension of the soil. This rate of fixation would add essentially 1½ tons of proteid matter to the acre-foot of soil in 48 days. This sample gained 23.3 parts per million of nitric nitrogen in this time. This gain was, of course, at the expense of the proteid nitrogen contained in the soil.

The vital question in this connection becomes simply this: Can these processes continue until such concentrations of the nitrates as we actually find are brought about? In other words, are we assigning to these bacteria a measure of activity and endurance which they do not possess? According to Dr. Sackett, we have areas so rich in total salts, not necessarily nitrates, that the *Azotobacter* seem to have been killed off, but at the edges of these areas and at slight depths not only are the bacteria still living but the edges prove to be areas of great activity.

We believe that the facts adduced not only present the least strained explanation for the formation of these nitre-spots but amount to direct proof that this is their origin.

The most serious objections that have been offered to this view are, first, that the scale in which the nitrates occur requires an activity, both in intensity and duration, of which the *Azotobacter* probably are not capable. We have just offered our answer to this

by showing that an ordinary soil, the one on which we made our wheat experiments, added practically 1½ tons of proteid matter to the acre-foot in 48 days. So far as I know this objection as made pertained to the question of fixation and not to ammonification and nitrification. The question of energy to support this activity is effectively answered by the fact that the soil without addition of any source of energy fixed 124 parts per million of nitrogen in 27 days. It is, however, a fact that this soil is rich in algæ, which may furnish the energy.

A second objection is that the nitrates may not have been formed where we find them, *in situ*. In my view that these spots owe their existence to bacterial activity, it follows that the nitrates are formed *in situ*. We have, however, considered the possibility of their having been transferred to the spots and areas where we find them. The only means of transportation is water, and a great deal of labor has been spent directly and indirectly upon this possibility.

It is well known that nitrates are often found in small quantities in phreatic waters. These quantities seldom exceed a few parts per million and their source is considered to be found on the surface; in fact, they are considered as a sign of pollution. The results of long observation has led us to these conclusions. First, our river waters taken in the mountainous sections are free from nitrates; our ground waters, except in sections where nitrates occur on the surface, are free from them; so as a general proposition the waters of our country do not carry nitrates and the general proposition of concentration cannot be entertained. This is true of drainage waters and of both deep and shallow wells. We have endeavored to show both by the actual presence of nitrates in large sections of country and by their specific effects upon the growth and properties of crops, especially upon the sugar beet, that this question is a general one of which the nitre-spots are only exceptional features.

It may be suggested, in fact, has been suggested, that these spots represent concentrations of nitrates from adjacent lands formed therein by this general condition. This special or local concentration has received close study and we have shown that it does not take place. A specific case will make plain how thoroughly justified we are in making this statement. We found a piece of land in which the nitrates occurred abundantly, amounting to upwards of 3000 pounds in the surface two inches of soil per acre. The Grand

River formed the south boundary of this land. The land back from the river was higher and the water flowed from the higher land under the nitre area. The soil, the alkalies which occurred on the soil, the ground water and the water-soluble portion of the soil were all analyzed, but found to contain no nitrates. We consider this positive proof that the nitrates found on the surface of this soil did not come from the immediately adjacent land or from any other, or the ground waters would have carried them. There was another piece of land with nitre-spots equal in richness to the ones just given and similarly located. There were 4 drains running east and west through this land, besides it was protected by a north and south drain on its east side. Three of the east and west drains carried no water except when the land was irrigated. The rainfall in this section is usually not sufficient to produce a flow in these drains. The fourth drain, the most northerly one, furnished a continual flow of water. This water was analyzed and found to contain 0.1 part per million of nitric nitrogen. This, as well as the ground waters previously mentioned, was rich in total solids or in alkalies. This is a direct refutation of the suggestions that the nitre-spots are the products of concentration from surrounding lands by the agency of water.

In this case, and generally in all cases, an insurmountable objection to this theory would be the difficulty in accounting for these very soluble nitrates without a very much greater concentration of the much less soluble sulfates and chlorides at the same time and in the same place.

The preceding facts given relative to the concentration of nitrates from adjacent lands also refute the suggestion of some deep-seated source of these nitrates. This suggestion is further refuted by the practical absence of nitrates in the case of waters from deeper wells.

The following cases may serve to enforce this fact. In a very bad piece of ground we found in the surface 3 inches of soil from 0.3 to 0.6 per cent of nitrates calculated as sodium nitrate; in the ground water as it flowed into a cellar which carried 17,561 parts per million of total solids, we found 878 parts of Nitrates or 5.0 per cent of the total solids calculated as sodium nitrate, while in water obtained at a depth of 19 feet we found no nitrates. This was rendered possible by the impervious nature of the overlying shales and clay. In another case, in a different section of the state, 200

miles in a straight line from the preceding case, where we have extremely bad conditions on the surface, we found in the ground water, encountered at a depth of 4 feet, 9,908 parts per million of total solids, of which 28.09 per cent, or 2,783 parts per million, were nitrates; and in the water from a drilled well 280 feet deep we found 5,328 parts per million of total solids and 6.6 parts per million of nitrates, or 1.1 parts per million of nitric nitrogen. The 19-foot hole and the 280-foot well penetrate the underlying Cretaceous shales.

I might multiply such instances very greatly. Perhaps the most striking cases to persons not acquainted with our conditions occur in the San Luis Valley, where none of the objections offered to my views regarding the origin of these nitrates can apply, except the doubt as to the adequacy of the bacterial flora to accomplish the production of such quantities of nitrates. In this section the mountain streams flow directly into the valley. The collecting grounds of these streams are either igneous of metamorphic rocks. The waters delivered to the valley, which is about the size of the state of Connecticut, are free from nitrates. The artesian well waters in the southern section of the valley are almost identical with the river waters in composition, while those of the northern and eastern section are decidedly alkaline. However, both are free from nitrates, and yet I have found the most remarkable occurrences of nitrates in these sections—in one case amounting to 5.6 per cent of the surface soil and in another 14.14 per cent. The former of these occurrences has disappeared and apparently the latter also, as a result, I believe, of the extermination of the bacterial flora as already noted.

In this valley we find remarkable concentrations of alkalies, both sulfates and chlorides, without any nitrates.

I hope in the near future to take up the more general question of the occurrence of nitrates, as this is the clearly indicated course for the continuance of this investigation. It is well known that nitrates occur in the surface portions of many rocks, sandstones, arenaceous limestones, in igneous rocks of various kinds (I have in mind particularly rhyolites), but so far as I know the occurrences are not confined to these.

I have occurrences of nitrates on rocks to which the usual explanations, volcanic gases, animal excretions, etc., cannot possibly apply. In special cases these may be the actual sources, but it appears to me that there are not insects or birds or bats or rats enough to cover the

faces of mountains and cliffs with even the slight amount of nitrates which are on the surface only and not in the rocks. I have a case in mind in which I found from 2 to 60 parts per million on the surface of a cliff and 0.017 parts per million in a newly opened tunnel possibly 50 feet under cover.

While there is much work still to be done, I am convinced that no refutation has as yet been made of the theory that the nitrogen of these nitrates is derived from the atmosphere through bacterial agencies.

Poisonous Plants

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GENERAL

The poisonous plant problem, while confined to certain restricted areas, is nevertheless responsible for losses of considerable magnitude among stockmen. Available statistics are lacking, but from an estimate based upon losses in several localities it seems probable that the average must be as great as 5 per cent. In Wyoming, sheep growers have estimated a loss at approximately 14 per cent. Other states are known to have incurred annual losses aggregating several millions of dollars. Further, it appears to be extremely likely that many deaths due to unascertained causes are really due to plant poisoning.

It is evident that as the area of the stock ranges is reduced and the value of the livestock increases, owners are necessarily using more care in range management. The desire to determine the "specific" troublesome plant is growing. Usually, the first suggestion of trouble has been the finding of dead carcasses and then "poison weed" is advanced as the cause, although no particular weed is designated. While the number of plants is comparatively high, yet those known to be particularly dangerous are far less numerous than ordinarily supposed. So, with the aid of trained botanists and the use of government bulletins, every ranchman should be able to acquaint himself with the prominent characteristics of plants in his own territory. Through the inability to recognize dangerous plants many owners suffer losses year after year, thinking that some other cause is responsible.

In the matter of prevention and treatment we find a favorable tendency to utilize and disseminate information of known value. Logic and good judgment are replacing many traditional practices that, in themselves, have no value and in certain cases have proved decidedly detrimental.

CONTRIBUTORY CAUSES

Contributing factors incidental to plant poisoning are indeed numerous. Ordinarily, plants are protected from animals by various

means, such as unpleasant odor, acrid or bitter taste, toxic character, and in some cases such protective devices as spines.

The depraved appetite for unusual and unappetizing food plants is a factor responsible for many cases of poisoning. In the early spring animals are often tempted to eat dark green plants of luxuriant growth which are soft and succulent. In a state of nature, animals, as a rule, avoid instinctively such plants as are "toxic" and appear to be less readily poisoned than those imported from a district where they do not occur. Sheep are particularly variable in their choice of plants, not only individually in the flock, but from day to day. I have often observed sheep eating greedily on one day, plants which they could scarcely be persuaded to eat on the following day on the same range.

The susceptibility of different species of livestock is an important factor. One species (e. g., the pig) may readily vomit the poison of a plant which is emetic, while another (e. g., the horse) may be unable to do so, and hence be more seriously affected. Aside from the individuality and susceptibility of an animal, we find that its physical status and the condition of the range greatly affect the actual losses from plants.

The principal poisonous plants of more or less general distribution may be classified into two groups: first, those that occur rather generally distributed and in large quantities in several states; second, those found locally and in more or less restricted areas, often only in a single state. In the former would be included the locos, the larkspurs, species of death-camus, water hemlock, the vetches, the lupines and aconites. In the latter group, one would probably name the laurels, the ferns, the milkweeds, woody aster, western sneezeweed, wild cherry and oaks. Possibly in discussing poisonous plants mention should be made of the fact that forage plants are sometimes infested with fungi, such as rusts and molds. These may be the cause of the poisoning when found on forage which is ordinarily entirely harmless.

LOCO

It is commonly agreed that the locos are the most destructive of all the poisonous plants. This term, however, covers a wide range of species and is not even confined to a given genus. The two most nearly related genera supplying locos are *Oxytropis* (*Aragallus*)

and *Astragalus*. In the genus *Oxytropis* there are a number of closely related species which some botanists prefer to consider as sub-species of the one first described, namely, of *Oxytropis Lamberti*. The original form of this should properly be called the "purple loco." The closely related ones more recently described are *Oxytropis albiflorus* (white flowers) and *Oxytropis spicatus* (cream-colored flowers). These three species very possibly have the same toxic properties, but experimental evidence is needed upon this point. In this same genus there are other suspected species, but the three mentioned really include all those upon which we have definite knowledge. These, whether they are locally known as purple or white locos, are to be credited with more losses than all of the other members of the group put together. In the genus *Astragalus* there are two species that are notably poisonous. The one is known as the "Woolly loco" (*Astragalus mollissimus*); the other as the "Two-grooved vetch" (*Astragalus bisulcatus*). The word "loco" comes from the Spanish and was applied to any plant that apparently produced madness or mental derangement in animals.

The active principle involved in producing the loco disease is a slow poison and apparently cumulative. It differs from most poisons in that animals appear to create an appetite for it. The disease is chronic in form, affecting the nervous system primarily. Positive symptoms and a definite outcome point very clearly to the presence of an active poison. Just what it is we do not know, although during the past quarter of a century the subject has received careful consideration in the field and laboratory. Investigations are still in progress and it seems reasonable to assume that, with the application of well-defined principles of biology and chemistry, the secret activator of locoism will be brought to light.

LARKSPURS

The fatalities occasioned by larkspur poisoning in western cattle herds is surpassed perhaps only by loco. Losses have been reported from all the mountain regions between Mexico and Canada and from the Rocky Mountains on the east to the coast on the west. There are several poisonous species of larkspurs and for convenience we may divide them into two groups, the tall and the low. Representative types of the former, and most generally associated with mountainous areas, may be mentioned, *Delphinium barbeyi*,

Delphinium cucullatum, Delphinium trolliifolium, and *Delphinium glaucum.* Characteristic low species include *Delphinium menziesii, Delphinium geyeri,* and *Delphinium bicolor.*

The toxic ingredient of the larkspurs is alkaloidal and is found in all parts of the plant in varying quantities. Regardless of the character of the plant, poisoned animals exhibit symptoms essentially the same. Death, in each case, is caused by respiratory paralysis. In some cases, bloating is pronounced, and if the animal is immediately relieved it may rapidly recover the mechanical shock and show no further effect. It is probable that the poisons inhibit the activity of the abdominal tract to a certain extent and thus accelerate the formation of gas. The fermentative products may be the result of the rapid fermentation of simple sugars.

A careful chemical and pharmacological study has been made at this station of four distinct species of larkspurs. Each plant presents alkaloidal types of a different character. The stage of growth is a factor of considerable importance, inasmuch as the quantity of poison varies with the plant's development. In most cases there is a decided change in the form of the poison when compared with two or more periods of growth. The one exception so far noted is that from *Delphinium glaucescans,* which yields a crystalline alkaloid throughout its growth. It is the only alkaloid so far isolated from the larkspurs that is optically active. The system and class of the crystals is also distinctive.

Aside from the specific poisons present there is a considerable quantity of free acid which, in my opinion, is indirectly a factor materially affecting the activity of the plant's toxicity. The acid has been reported to be Aconitic, but careful research has disproved this. It is a related acid, however, and is possibly one of two theoretical isomers. I should like to discuss the relationship of this interesting acid to the alkaloids, but I fear my time will not permit.

LUPINES

Closely following the larkspurs in causing a large death rate, especially among sheep, may be mentioned the poisonous lupines. Important and representative species include *Lupinus argenteus, Lupinus leucophyllus, Lupinus sericeus,* and *Lupinus cyaneus.* The plants are, as a rule, scattered, but occasionally dense patches are found as illustrated by *Lupinus humicole.* Generally speaking, the

lupines are dangerous to stock after the first appearance of the green pods. Of course, not all the toxic species show the same degree of activity. The well developed seeds are no doubt the most dangerous, although several authenticated cases of poisoning have occurred from animals having eaten the unripe fruit. The mature pods of *Lupinus argenteus* proved to be far less toxic than those in the green undeveloped condition. The quantity of poison in the ripe pods is also appreciably less. The composition and specific characteristics of the poison have not been definitely determined.

DEATH CAMUS

Death Camus, occasionally referred to as "wild onion," is widely distributed. There are three varieties commonly known, *Zygadenus venenosus, Zygadenus elegans,* and *Zygadenus paniculatus.* Death Camus is poisonous to all classes of stock, especially sheep. All parts of the plant are poisonous. More losses appear to occur during the spring and early summer. The seeds from *Zygadenus paniculatus* are reported to be very poisonous.

The active principle is alkaloidal and from careful chemical and pharmacological studies it is apparent that the poisonous properties of *Zygadenus* are essentially those of veratrin. A crystalline alkaloid was isolated at this station by Heyl, Hepner and Loy, and given the name of *Zygadenine.* It seems doubtful as to this being the important toxic agent, since its action is slow and relatively large doses are necessary to produce death.

WATER HEMLOCK

Poisonous water hemlock, botanically known as *Cicuta,* is a bulbiferous plant occurring widely distributed. The botanical character of *Cicuta* is greatly modified by its geographical location. *Cicuta maculata* and *Cicuta occidentales* are typical species. Careful tests made by the Bureau of Animal Industry indicate very clearly that this plant is the most poisonous of all plants in the United States. The toxic principle, cicutoxin, occurs mostly in the root-stocks, and as a consequence its activity is greatly modified. It is resinous in nature and does not give a reaction with any of the ordinary alkaloidal reagents. All classes of stock are susceptible, although, on account of conditions, it is probable that the largest losses occur among cattle.

ACONITES

Aconitum columbianum is the most common variety of the poisonous aconites. Its habitat is closely associated with that of the tall larkspur and is often confused with it. The losses from aconite poisoning are comparatively small. According to Professor Chestnut, the seeds and roots are the most dangerous. The active principle is not well known, but chemical and physiological experiments point to the presence of one or more alkaloids which resemble aconitine.

Vetches (*Astragalus* sp.)

The vetches present a particularly difficult class of plants to discuss largely because accurate information is lacking and the additional fact that the symptoms resemble to some extent those of loco, and hence the vetch disease is frequently reported as loco poisoning. A large number of species exist and several are regarded as suspicious. One variety, *Astragalus bisculcatus,* commonly called the "two-grooved milk vetch," has been found to be decidedly toxic. The poison is rather slow in its action, but after the disease becomes well established very few animals recover. Cattle appear to be more susceptible than other classes of stock. The stems, leaves, flowers, seeds and pods contain the poison quite evenly distributed. The causative agent is non-alkaloidal in character and extremely soluble in water. My preliminary experiments clearly point to the presence of a glucosidic body. The first pronounced physiological effect is the inhibition of abdominal activity, this followed by a rapid loss of flesh, defective vision, and a general weakness.

LAURELS

A class of plants known as laurels are reported to have caused heavy losses in certain localities, especially among sheep. Five varieties are mentionod as being poisonous. The active principle in all the laurels is andromedotoxin. It does not react with the ordinary alkaloidal reagents.

Woody Aster (*Xylorrhiza parreyi*)

Woody aster is confined almost exclusively to Wyoming. Sheep appear to be the only animals affected, largely because other stock persistently avoid it. The poisonous substance recently isolated at this station is a nitrogenous organic acid, and is extremely toxic. I

regard it as a dictinctly different type of poison from any heretofore separated from any of the toxic plants. When neutralized with an alkili its poisonous nature is greatly modified.

Western Sneezeweed (*Dugaldia hoopesii*)

Recently western sneezeweed is reported to have occasioned losses among sheep in certain states, especially Utah. The poison is slow in action and said to be cumulative. Its specific nature has not as yet been announced.

Wild Cherry

Under certain conditions wild cherry leaves have been responsible for heavy losses, particularly among sheep. The active poison is prussic acid, which is probably liberated by suitable plant enzymes acting upon a glucosidic body.

Milk Weed (*Asclepias verticillata*)

The whorled milkweed appears to have caused heavy losses, particularly in Colorado. The poisonous nature of the plant seems to have beeen conclusively settled by Glover, Newson and Robbins of the Colorado Agricultural College. The active principle has not been reported.

OAK

Several species of the oak have been found to poison cattle, especially when grazed exclusively upon oak leaves for a considerable period of time.

FERNS

Concerning the common bracken fern there seems to be no doubt that it has poisoned horses, cattle and sheep, especially when the animals were allowed to eat it in fairly large quantities.

METHOD OF CONTROL

The list might be easily extended, but I feel that the important poisonous plants have been mentioned. It is apparent that from whatever angle the problem is viewed the solution is by no means an easy one. The varied habitats, the character of the active principles, methods of treatment under range conditions, are in themselves barriers which require, at all times, the best efforts of specialists on one hand, cooperating with the stockowners on the other, to reduce

losses to a minimum. And even then we are forced, at times, to witness losses which might have been avoided had warning been heeded. The following is given as an illustration. A band of 17,000 sheep were unloaded July 17, 1917, at Warland, Montana. The sheep had been in transit 48 hours and naturally were very hungry. Unfortunately, the men in charge went on a protracted "spree," and the sheep were allowed to drift at random. The result was that between six and seven hundred sheep died from eating death camus. The same owner suffered a similar loss at the same place in 1915. The forest supervisor had warned him on each occasion concerning the presence of the poisonous camus. Had the sheep been properly fed upon arrival it is probable that not a single death would have occurred. Instances of this kind clearly explain the relationship of hungry animals and poisonous plants. Prevention can be practiced, and is, of course, in the majority of cases.

The inability to recognize poisonous plants has been a source of losses to stockowners. The Bureau of Animal Industry, realizing the necessity of this long-felt need, has recently published an illustrated bulletin entitled "Stock Poisoning Plants of the Range," which should prove to be a valuable contribution.

I hope the day is not far distant when each western state will insist upon having an accurate poisonous plant survey. If it is worth while for the National Forests, why would it not be advisable to extend it to the open ranges? Such a plan would serve at least two purposes: first, every stockholder would have accurate information as to the kinds of poisonous plants in his immediate vicinity; second, in trailing animals over strange territory advice in advance concerning possible "poison areas" would be quite acceptable.

The one-night camp for sheep, in my opinion, should be given careful consideration by sheep owners. The shortage of feed that naturally results in the immediate vicinity of a more or less permanent camping ground of necessity tempts sheep to eat injurious plants that ordinarily would not be touched. The bedding-out system appears to be practical and has many advantageous features other than eliminating hunger by unnecessary trailing.

Animals, particularly sheep, when not given sufficient salt acquire a depraved appetite for toxic plants. Convincing evidence concerning this point is given by the Department of Range Management of Nevada. The selection of shearing pens with reference to poison-

ous plant areas is of considerable significance. Not many years ago it was a general custom to drive sheep many miles to central shearing pens. It quite frequently happened that these sheds were located in the midst of dangerous plants. After the sheep were held several days without sufficient food their appetites would become depraved and upon trailing through poisonous areas the results many times were disastrous. To-day we find a general improvement all along the line. Unnecessary trailing is reduced by increasing the number of sheds and more care is taken to avoid those plants which have given trouble in the past.

ECONOMIC CONSIDERATIONS

In conclusion, I cannot refrain from suggesting that poisonous plants should be exploited for products of commercial value. If a leaf of the wild cherry will kill a sheep, why will it not kill several prairie dogs? The Biological Survey uses large amounts of strychnine for this puropse, which is expensive, bitter and dangerous. The poisonous plants grow in abundance and are a source of harm. Their utilization will serve two purposes: first, it will lead to their elimination, and second, to the production of perhaps valuable products.

The resins from the European larkspurs have known insecticidal value. This property is not due to the alkaloids in the resin. We have large quantities of larkspur in this country and yet we know comparatively nothing of its value. Several poisonous plant species contain mannose. The possibility of its utilization as an explosive warrants further study.

Practically nothing is known concerning the medicinal value of the active principles in the various poisonous plants native in the United States. Since ancient times European lupine seeds have been used as a medicine and one author enumerates 35 different applications. We know that our native lupine seeds have occasioned enormous losses to stockowners, but as to their utilization commercially our query is unanswered.

Use of Wood for Fuel

F. W. Rane

Massachusetts State Forester

The time has come to consider well some of the fundamental problems bound to affect our future economic existence as a people.

The economic value of wood for fuel has not been adequately appreciated.

Wood was practically the only fuel used in New England half a century ago. Up to the beginning of the present war our development had been so rapid and nature had been so lavish with her many resources, such as coal, coke, gas, petroleum and its by-products, and finally electricity, that they were used regardless of their economic importance or resultant effects.

In the sudden coming of a world war which quickly demanded our surplus, a war in which we demonstrated a willingness to do our full share, we have been taught extremely valuable lessons that otherwise might have remained unseen and unappreciated.

The fact that coal was indispensable for war purposes, together with the further facts that transportation became congested, that submarines were taking their toll, and bridges were in danger of destruction, caused general alarm. The results were not as bad as they might have been, but to say the least, they were not altogether pleasant.

Suppose, for instance, a few bridges over the Hudson River had been destroyed by the enemy, thereby interrupting railroad traffic, or had the submarines been a little more successful in crippling our coastwise coal fleets, it is not difficult to imagine how terribly New England people would have suffered from cold, to say nothing about the loss to manufacturing industries in which this section is so largely engaged.

No, it was not until cold weather was upon us that we found we could fall back for domestic fuel on wood, and when conditions became so bad that heatless Mondays came, it was even green wood that came to the rescue.

During the early part of the season the State Forester's Department had been able to increase the usual cut of fuel wood, but when January and February arrived, the shortage for domestic consumption was increased by many of our manufacturing plants, unable to secure bituminous coal, using the fuel wood reserve at prices heretofore unequalled.

By way of contrast, it was only four winters ago that the Massachusetts State Legislature was confronted with the great need caused by the lack of employment for many of our citizens. In order to relieve the situation, a sum of $100,000 was placed in the State Forester's hands, by an act of the Legislature, to enable him to give work to the really worthy and needy unemployed. That year a great quantity of fuel wood was cut, and it was not uncommon for brick yards to purchase it on the lot in 4-foot lengths for prices ranging from $1.50 to $2.50 a cord. Last winter $10 to $18 a cord for green wood was the common price. At the present time seasoned cleft 4-foot hard wood is bringing $9.00, f. o. b. the cars in most sections of the state. If to this is added $2.00 a cord for freight, and a dollar or two for delivery, and again $1.50 for sawing into smaller sizes, the normal expense for fuel wood ready for the stove, hearth-fire, or furnace, will average from $13 to $15 a cord. This should be first-class cleft hardwoods, such as oak, beech, birch, and maple. For poorer grades, where there are mixtures of soft woods and chestnut, this price should be one or two dollars less. In case the wood is near a market, the freight could be deducted, but generally the average extra haul will offset this.

One of the good results likely to come from our recent experiences is the recognition of the value of wood as a fuel and its real place in our economic existence. While it is claimed by the authorities that they have no power to regulate the price of fuel wood, it is inconceivable that public opinion will recognize such excuses. Does it matter whether we perish by lack of food or freeze to death? The regulation of wood fuel prices, particularly in New England and the north, is fully as important at this time as the regulation of food prices.

After studying the situation the writer believes that if in the future more attention is given to the problem of cutting fire wood into convenient usable sizes that can be delivered at reasonable

prices, a continued dependable demand will result. This will particularly be applicable to the more thickly populated parts of the country like New England and similar other hard-wood sections.

The idea seems to be prevalent that wood for fuel is expensive as compared with coal. This subject is certainly debatable, and again depends upon a great many conditions. Upon a close study it is believed there are circumstances under which wood for fuel is more economical than coal; and again where wood is used in combination with coal, as, for example, in the spring and fall, and at times throughout the year when only a little heat is needed and for a relatively short time, wood is the cheaper fuel.

In speaking of wood for fuel, one must realize that there is a great difference in the various kinds of wood; in that respect the latitude is far greater than it is with coal, anthracite in particular.

This subject has been gone into to such an extent by the various state foresters, and there is so much literature in the form of bulletins available from this source, and from the United States Forest Service at Washington, D. C., that it is not thought best to weary you with the data in detail. When a cord of wood of one variety is capable of giving off twice as many calories of heat as a cord of another species, and we have a very large range of kinds of wood, it is evident that a knowledge of heat values of the various species is necessary for results. This knowledge was more common a few decades ago than today. We shall have to adapt ourselves to the utilization of wood for fuel. It certainly is not right to have wood going to waste in this state and in many parts of the country, while at the same time people are suffering from a lack of fuel.

By a study of conditions, the subject of utilization of wood for fuel can be made to fit into our modern methods of living.

Cordwood or wood fuel is in reality a by-product of the forest. In order to succeed in growing lumber, it is imperative that judicious thinnings or improvement cuttings be made. It is as necessary as thinning out one's vegetables in the garden. If no thinning is done, the product is of little value. On the other hand, a good gardener not only cultivates, thins, and gives his crops a great amount of attention at great expense of labor, but he relies entirely on the final crops to pay him for his undertaking. Forest

thinning is the weeding-out process, and unlike the garden, the product has its commercial value in wood fuel which if cut into convenient sizes will be eagerly sought after and used by our people. The final crop, or lumber crop, is thus not only improved in quality, but returns a larger net revenue to the owner.

In order to utilize our non-agricultural lands, it is incumbent upon us to make use of our natural resources in the best possible way. The present world war has shown us how we can improve conditions in many ways, and one of them surely is to make use of natural fuel all about us. It may require some readjustment in our heating equipments, better and more economical ways of production and distribution, and again, education in the real merits of wood as a fuel.

It is proposed in Massachusetts that henceforth we interest people in a state-wide movement to use more wood for fuel even after the war terminates. We are confident that its use will be sought by people. Our main dependence will undoubtedly be upon coal as usual, but from our recent experience we feel that the real value of wood as an auxiliary fuel will be more and more recognized.

Instead of selling wood in 4-foot lengths, not a desirable size for use, if it should be cut into smaller sizes as 8, 12, and 16-inch sizes for furnaces, and 2-foot lengths for the hearth fire, and thus made more convenient and usable, the demands for its use would be greatly augmented. The delight taken by the city-bred in the attractiveness and cheer of the hearth fire when in the country may be had in the city as well by more judicious management on the part of all interested from the woodlot owner or farmer to the consumer.

One of the experiments the State Forester in Massachusetts is carrying on at the present time is in interesting cities and towns in owning at public expense a portable circular saw-machine which is placed in the hands of the local town forestry official who uses it for the purpose of first improving the forestry conditions in the town. Dead and dying trees, in themselves unsightly and suited only for fuel are thus utilized. The town forester and his employees not only work for the town in their official capacity, but they likewise are employed by private citizens at cost, which includes a nominal charge for depreciation of the sawing machine. This

work carried out throughout the town constantly improves the conditions, it naturally follows that the products, that is, wood fuel, are likewise of value and much sought after. Should there be an excess in any one place, it readily finds a market in cities. The experience thus far has been that the demand exceeds the supply and once the wood is cut into usable sizes, it finds ready sale.

It is imperative that those of us who are charged with the responsibility of public leadership in forestry matters give this subject its due consideration at the present time. Our great weakness in the past has been in being unable to utilize the poorer qualities of lumber and forest products at a reasonable profit, or even to break even. Hence untold values have wasted. These conditions are vanishing as our country is rapidly becoming a world power, and hence depended upon to furnish every conceivable resource.

The rapid depletion of our forests for lumber, ties, poles, ship timber, pulp, etc. is followed by the more recent chemical utilization of wood that is coming by leaps and bounds. Every forester of the nation should be sent to the United States Forest Products laboratory, at Madison, Wisconsin, to keep abreast of the modern demands that are bound to come in the various uses of wood in the future. The chemical utilization of wood that has sprung into existence because of the present war is probably little realized by many. The government has established immense plants for the production of acetate of lime, acetone, wood alcohol, charcoal, wood tar, etc., while our commercial manufacturers of these and other wood products have greatly enlarged their plants. Tannin, dyestuffs, and powder manufacturers have also laid great demands upon woods of various kinds. If to this end we add the innumerable uses of wood from the fibre or pulp wood base, such as paper, twine, silks, furniture, suit-cases, rugs, pasteboard, etc., we shall not yet have exhausted its possible uses. Our technically trained scientists have only made a beginning in the utilization of this natural resource. It has been only recently that chemists have demonstrated that alcohol can be made from saw dust; also there are a few plants already extracting a substitute for butterfats from wood as a by-product, and who knows what next?

In closing, the writer simply desires to say that he is not in the least concerned about the future uses of woods of all kinds, as

they are bound to be one of our greatest assets, and we do well to conserve in anticipation of that day.

Meanwhile, while we are yet feeling our way in the dark, let us take advantage of our natural birthright, in our forests, and use and enjoy wood fuel economically and well.

It takes a world war to bring us to the realization of our real blessings in natural resources all about us, heretofore little appreciated.

Relation of the Society for the Promotion of Agricultural Science to Agricultural Extension

D. W. Working

United States Department of Agriculture

In the presidential address at the second annual meeting of the Society for the Promotion of Agricultural Science, Dr. W. J. Beal attempted to state the objects of the society, his program consisting of fifteen points, the thirteenth of which was stated in the following words:

> To encourage agricultural education; to encourage and approve good work done by anyone in the United States Department of Agriculture.

It seems worth while to consider for a few moments this thirteenth point with the qualification implied in the title to the present paper.

When one considers the names and the work of the men who have given the Society for the Promotion of Agricultural Science its character and standing, it becomes evident that the society stands for what is sound and progressive in agricultural science and for a steady adherence to high standards of personal character and to strict faithfulness in public service. From the beginning a very large proportion of the society's members have been college teachers and experiment station investigators, and therefore in such relation to scientific agriculture and to the public that they were bound to exercise a great influence on the large body of students in attendance at the institutions they have represented and directly and through their students on the public. Thus, because of the high standards they set for themselves and by reason of their intimate connection with the developing sciences in which they worked and the seriousness and ability with which they worked and taught and wrote, these men came to represent the highest achievments in research and teaching in the various branches of what they called and have made agricultural science.

When the Society for the Promotion of Agricultural Science was organized in 1879, American agricultural colleges were barely at the beginning of their service to American agriculture. It is com-

mon knowledge among the members of this society that the original membership did not include the name of a single representative of the United States Department of Agriculture and that for a considerable number of years the Department had small influence in shaping the policies of the organization. It was proper, therefore, that the first president should recommend that half of the thirteenth object of the new society should be to recognize good work by Department men. Since then a considerable number of men connected with the Department of Agriculture have joined the society; but the latest list of members indicates that there is still opportunity for effective missionary work among the scientists of the Federal Department of Agriculture. This list shows that, of a total of 151 members, 81 per cent are connected with state colleges of agriculture and experiment stations and a few other educational institutions; that 13 per cent are connected with the Department of Agriculture; and that 8 per cent have other professional connections. The percentages given are not exact, and do not take into account a number of changes known to have occured since the list was compiled. Nevertheless, it is clear that the society is overwhelmingly representative of agricultural workers not connected with the Federal Department of Agriculture. And it might be well to consider whether there should be made a systematic effort to increase the membership of the society from among Department workers believed to measure up to the standards of the organization.

But it is not the purpose of this paper to advocate an increase in membership, however desirable such increases may seem to the writer. There has recently developed a situation which may be worthy the careful consideration of the society as a whole or even study by a special committee. From the condition when the president of the society could seriously propose patronizing good work that might happen to be done by the Federal Department of Agriculture, it is a far cry to this advanced day when practically all the agricultural colleges of the country are engaged with the Department in carrying forward a well-considered and liberally endowed cooperative enterprise; and are doing this work under definite signed agreements to cooperate according to plans worked out by college deans and presidents on one side and the Secretary of Agriculture and his representatives on the other.

It needs only to be mentioned in passing that most of the state agricultural colleges and experiment stations owe their origin and all of them a large part of their endowments and growth to the Federal Government. Without the Morrill and Hatch Acts and their amendments we could not have developed the system of agricultural education and research represented by the land-grant institutions; this is well understood. Without the Agricultural Extension Act of May 8, 1914, we could not have organized the big cooperative enterprise now developing under the provisions of that act and the agreement known as the General Memorandum of Understanding governing the cooperative agricultural extension work, which is making available, in a greater degree than seemed possible a few years ago, the results of the research and teaching of the colleges and the Department of Agriculture.

The relation of this society to this new work is the question we wish to consider now.

Without implying or suggesting any lack of competence or faithfulness on the part of public institutions or those charged with their management, it may be stated as a general principle that every such public institution should be watched and guarded by some competent and disinterested agency representative of the public. It is inevitable that every such agency as a state agricultural college or the United States Department of Agriculture should feel bound to assume its own competence and usefulness in its own field; and it seems to be inevitable also that, when a group of such institutions enter into an agreement to conduct a large cooperative undertaking with public support, there will be a growing tendency for the several members of the cooperating group of institutions to believe more strongly in their work as it increases in efficiency and in the number of workers engaged in the common enterprise. We expect to improve our organizations from within. We believe in our own ability and integrity. Notwithstanding your academic freedom, you college men would resent any charge that you are or could be disloyal to your college or university; in the councils of your institutions all of you feel bound and free to offer constructive criticisms; and some of you feel free to use the pages of "Science" and other publications for the purpose of making criticisms which certain other persons do not call constructive. And you who are connected with the Department of Agriculture are

ready to insist on your right, within proper limitations, to criticize among your associates the plans and policies of the Department; yet you too would resent any charge that you lack in loyalty to the organization of which you are a part. Doubtless most of us would be ready in a pinch to defend our personal and professional integrity with our resignations; doubtless also there are men who withhold needed criticisms because of their employment by the institution which seems to need criticism. Always there is the possibility that motives will not be understood and that the man within a college or other organization may be too close to what seems to be an evil thing to see that it is actually a good thing. And the contrary may be true. Even wise men like ourselves have their limitations, knowing too little or too much, or thinking narrowly when we should think broadly, or mistaking the applications of our knowledge or our plans.

All this implies what all of you well know—that in most games honestly played there is need of an impartial umpire. Is it too much to hope that there can be a scientific umpire competent to know the purposes and organization and methods of work of the agricultural colleges and experiment stations and the United States Department of Agriculture, and also to stand squarely as the judge of these institutions and their work and to serve also as the spokesman for the public which these institutions were established and endowed to serve? The fact is not overlooked that the public has organs of criticism. But it is believed that an organization such as this, whose purpose is the promotion of agricultural science through teaching and research agencies supported by the public, is competent to a degree that no non-scientific organization could be to offer constructive and corrective advice and criticism.

In the early days this society numbered among its members a number of editors of agricultural journals. There seems to be no sufficient reason why it might not now find a considerable number of such men eminently qualified for membership. As a result of the teachings of the agricultural colleges, there are now hundreds of farmers as well trained in certain branches of agriculture as some of us. Possibly such men would welcome an invitation to join this society and to give it the benefit of their support in its more technical activities and to add the positive contribution

~~shall agricultural science be promoted? It is easy to answer, "By~~

of their practical knowledge and experience, it is to be remembered that the public which supports our research and teaching agencies gives its support in the fond hope that these public institutions will render real public service—a service which many are prone to measure only in terms of improved plants and animals; in increased production from the farms and ranges; and in the better qualities of product and the larger profits which appeal with considerable force to most men and women.

What has thus far been said is intended to raise questions rather than to offer opinions or to propose any particular course of action. But all along I have had a particular thought in mind—the thought that this society can serve the public by giving a considerable share of its time and thinking to the work of the agricultural extension agencies now so actively at work in every state. The purpose of the society is to promote agricultural science. How shall agricultural science be promoted? It is easy to answer, "By research, publication, and teaching." Possibly a few of our members would limit the work to the promotion of research and the publication of the results of such research. Many of us would insist that the investigator must first find facts and then interpret them. Doubtless most of us will agree that the man on the farm expects our science to prove its value by its applications to farming. The extension workers are accepting this view; the proof of the scientific pudding is found in the eating—that is, in the actual application of facts and theories to the practices by which farmers raise crops, breed and feed their animals, and perform all the acts included in the miscellaneous operations which must be carried on by the man engaged in agricultural pursuits for pleasure or profit or both. These men need to be encouraged to have sufficient faith in us and our work to keep them in the frame of mind to advocate or at least tolerate the voting of appropriations to keep our work going.

Most of you will have realized that the writer of this paper is engaged in cooperative agricultural extension work, and you will assume without argument that he believes in it. Most of you are engaged in college teaching or in research work connected with agricultural colleges and the Department of Agriculture; and it seems fair to guess that a large percentage of such men as you will occasionally have certain doubts concerning the thoroughness of the training of extension workers and certain fears regarding

the soundness of the teaching they are spreading so confidently among the farmers of the United States. Among extension workers such doubts and fears have been entertained, even though discretion withholds expression. Some have believed that self-confidence is one of the characteristics of extension workers. The man of any doubts and hesitations is not likely to go far or fast as a leader. We need sure knowledge, correct interpretation, and safe application in our teaching. It has been intimated that all of our "demonstrations" do not demonstrate; that there is danger that we may get in the habit of using the word rather than the method; that much effort to teach the applications of science to the operations of the farm and household will result in looseness of teaching—in the flattening-out of the principles which men like you have been so careful to teach to college students.

Let it be confessed that extension workers are aware of certain of the dangers that you have seen or feared or suspected. It is not safe, however, to trust us to be our own mentors. It has been intimated or said that there is a difference in quality between "Washington Science" and science—the assumption being that the article called science is the genuine thing and the other kind more or less diluted. Is there possible danger that, unless this society can prevent it by setting proper standards and helping to maintain them, we shall have another kind of science—namely, extension science?

The writer of this paper has read an article by an experiment station director in which it was indicated that the research work of the experiment station was "fundamental" as contrasted with the "superficial" work of college and extension teachers. But the assumption of this paper is that the proper teaching of correct principles by the laboratory or lecture method of the college instructor or the demonstration or lecture method of the extension worker is and need be no less fundamental than the research work of the man who discovers the basic fact and first expounds its relationships. In other words, sound teaching in college classroom or in an extension worker's demonstration field is just as fundamental as the sound research work that established the fact on which the teaching is based. Let it be admitted that there is real danger that we shall talk too much and think too little or too loosely; that there is danger that we shall be so busy extending

the knowledge acquired in our college-student days that we shall not have time to acquire the new knowledge constantly becoming available; and that we shall not be able to give enough critical thought to the applications and interpretations of facts. Venturing to admit these dangers, I venture also in the name of extension workers to suggest that this society assume that our intentions are right and that we are willing and more than willing to be watched and guarded. Moreover, we invite the constructive and corrective criticism that sometimes seems to be less than sympathetic. As the representative and exemplar of the best in agricultural science, this society can do a genuine service as the friendly critic and guide of the ambitious and enthusiastic extension workers.

A Study in Community Cattle Breeding

J. H. Shepperd

North Dakota Agricultural Experiment Station

Twenty years ago the New Salem settlers had learned to work together. They shipped potatoes together. The entire community is organized into threshing crew circuits. These threshing circuits usually consist of 9 men—neighbors who together make up the threshing crew. One threshing group that I know, consisting of 9 men, live in an irregular line. On the odd numbered years they thresh for No. 1 first, No. 2 second and so on finishing with No. 9. On the even numbered years No. 9 threshes first and No. 1 last, while Nos. 4 and 5 always thresh in midseason. They have a threshing machine shed at each end of the line. They ship their sale stock together so as to make car lots. They bought their silos collectively, 10 to 12 in an order for their first silos. They have had a successful mutual fire insurance company for more than twenty years. The circuit men are of German descent. About half of the original circuit members have retired and their sons have taken their places in the circuit. They cooperate in many other minor enterprises. One primary cause of their success in cooperation is that they send small committees consisting of one or two men to make their purchases and sales. Their most productive and important cooperative enterprise is their dairy project.

They established the cooperative creamery at New Salem in 1897 and two years later one at Youngstown. The two creameries vied with each other in strong rivalry for six years, probably to the advantage of both. After six years of competition, rivalry ceased and cooperation between the two plants followed. Both are thrifty, successful plants.

In 1905 after considerable agitation and discussion of the question of putting in purebred cattle, which was strongly urged by the buttermaker of each creamery, several of the dairymen concluded to invest in some purebred stock.

Herman Krueger, one of the older men of the region, was the first to start it off by declaring that he was going to invest in some purebred cattle and that he had deposited a sum of money to be

used for that purpose. Mr. Krueger's decision brought others to the conclusion that they would join in the enterprise and arrangements were soon effected whereby a carload of purebred Holstein females were bought for individuals in the community. A year later I became interested in the plant and studied the conditions. I found that New Salem and Youngstown creameries had high-grade buttermakers, who were stimulating interest in high production and good quality of milk.

In 1909, when the writer first came in business contact with them and began to urge a cooperative breeding circuit, they regularly declared that while they produced both grain and livestock products, they regarded the livestock as the better and more dependable source of income.

The New Salem Breeding Circuit was organized in 1909 and effected all arrangements of detail so that records were begun January 1, 1910.

It was a cooperative breeding enterprise carried out jointly by the United States Department of Agriculture, the North Dakota Agricultural Experiment Station and the New Salem Holstein-Friesian Cattle Breeders' Association, until July 1, 1917, at which time the United States Department of Agriculture withdrew from the work. Representatives of each organization formed a committee which passed upon the sires which were used upon particular blood lines, and where necessary adjusted all matters of transfer, including the price to be paid by one member to another, etc. The Experiment Station and the United States Government, prior to July 1, 1917, maintained a man at New Salem who supervised the work of the circuit. Since that date the New Salem Breeding Circuit and the Experiment Station have maintained a superintendent. The superintendent makes such tests as are required for the permanent files and makes himself as useful as possible by suggesting improvements in feeding, housing and care of their herds.

Fortunately our committee has had little to do in making adjustments, thanks to the New Salem spirit of cooperation.

In 1915, through the process of suggestion, the owners of Hengerveld Ormsby Dekol 41,085 exchanged him for Sir Pietertje Ormsby Mercedes 12th No. 81,140. This involved five herds and five owners. Sir Ormsby Hengerveld Dekol carried three-eighths

of the blood of the world's champion cow Duchess Skylark Ormsby 124,514, with a record of 1205.9 pounds of butterfat while Queen Piebe Mercedes 154,610, who has since become the junior 4-year-old world's champion Holstein-Friesian cow with a record of 1,111.56 pounds of butterfat in a year, is a half sister of the Mercedes 12th bull. To try the spirit of the circuit to the limit the younger bull, Sir Pietertje Ormsby Mercedes 12th 81,140, then 5 years old, was believed to have become impotent. This was later found to be a mistake, but the bull had unfortunately been sent to the block on the theory that he was a non-breeder. To pass such a crisic with so many men concerned without a break in the circuit is certainly a credit to their spirit of mutual trust.

All herds have been kept free from tuberculosis and the sacrifices necessary to establish and maintain that condition have been hard on individual members at times. The circuit takes care of its advertising by deducting five per cent from all sales, which sum is placed in the general treasury and the circuit advertisement is carried. Other plans for securing publicity have been projected and may be instituted from time to time.

An adaptation from the Holstein Advanced Registry requirement has been worked out as a means of measuring what progress is being made on the New Salem circuit. It is a stronger requirement than the Advanced Registry Standard as the time is restricted to the calendar year instead of to any 365 consecutive days, as is the case in the yearly tests of the Advanced Registry Association.

The Holstein-Friesian Advanced Registry Standard requires 250.5 pounds of butterfat for a cow 2 years old with 1-10 pound added for each additional day of age until 5 years old, at which age and over, the production of 360 pounds of butterfat is required.

I have classified the cows on the Circuit on the basis of their performance record, dividing them into four classes.

1. Those which have exceeded the standard requirement.
2. Those which have come within 40 pounds of the standard.
3. Those which have come within 100 pounds of standard.
4. Those 100 pounds or more below the requirement.

In 1910 3 cows made Class 1.

In 1911 2 cows made Class 1.

In 1912 2 cows made Class 1.

In 1913 2 cows made Class 1.
In 1914 9 cows made Class 1.
In 1915 17 cows made Class 1.
In 1916 36 cows made Class 1.

In similar fashion the cows are getting out of the fourth, or poorest class.

In 1914, e. g., 6 cows on the circuit were listed in the fourth class, while in 1915 only one cow was listed in this class.

A severe drought in 1917 made feed and pasture so very short among circuit breeders that the cows had no chance to make even reasonably good records.

I do not flatter myself that improvement in the breeding is responsible for all of the increased production shown. Silos have been built and silage added to their rations. Grimm alfalfa has been grown and the circuit cows are getting the hay. Barns have been improved and circuit men are feeding more grain. All of these items have had an influence, but I am certain that the subtle thread of heredity has been in part responsible.

Following is the 2-year record of the best herd of the thirteen for the year 1916:

No. of Cows	Year	Butterfat	Cost of Feed	Net Profit
		lbs.		
17	1910	131.9	$27.25	$16.90
12	1911	140.7	24.66	13.20
17	1912	189.5	26.52	35.45
16	1913	211.4	38.99	33.09
10	1914	282.4	33.71	50.98
13	1915	291.8	37.09	54.50
14	1916	427.6	57.30	90.24

It will be noted that this herd started in with about a state average performance record in 1910, and in 1916 made a herd average of 427.6 pounds of butterfat, an increase of 224 per cent. The poorest record in this herd for the calendar year 1916 was 329.8 pounds of butterfat and the highest 524.8 pounds. The figures quoted are for his entire purebred herd of 14 cows. The circuit as a whole is showing good yields and butterfat progress.

In considering these records it should be remembered that they were made by dairymen in a new country where land is cheap and labor and improvements expensive. Rough and stony land must be used for pasture there which will force a single milk cow to graze

over seven or eight acres to satisfy her demands for grass. High production records are impossible under such conditions. The people who are to be supplied with breeding stock in the Great Plains region have similar conditions and will succeed far better with cattle used to such pastures and appointments than with cows accustomed to better care and feed.

The following are examples of the way individual cows are showing their capacities for producing high-performing projeny:

	DAUGHTERS
Dam....Nov. 10, 1908 Indi Pense Surprise 120,220....... 141.5 *lbs. above circuit* 1st *Class*	Oct. 6, 1910. Indi Aaltje Surprise 166,974 58.8 *lbs. above circuit* 1st *Class.* 1911. Bull calf Sept. 20, 1912. Indi Pauline Surprise 215,037 149.8 *lbs. above circuit* 1st *Class* Sept. 23, 1913. Indi Princess Surprise 249,653 156.2 *lbs. above circuit* 1st *Class* Sept. 28, 1914. Indi Squanto Surprise 290,370 76.4 *lbs. above circuit* 1st *Class* Oct. 12, 1915. Indi Hana Surprise 340,679 Oct. 18, 1916. Bull calf Oct. 10, 1917. Heifer calf

Indi Pense Surprise 120,220 is a large strong vigorous Holstein cow with a remarkable record for a Plains cow. During the calendar year 1916 she produced 501.5 pounds of butterfat with little special attention. During the summer of that season she grazed with the herd over native prairie pasture covering about eight acres of land for her supply of grass. She had very little concentrated protein food in the form of oil meal, etc. and during the greater portion of the year was milked only twice in 24 hours and with a milking machine. It will be noted also that during the 12-month period she had her vacation and started a second lactation period by calving October 18.

Her daughter Indi Princess Surprise 249,653 made 418 pounds of butterfat as a 2-year-old heifer and hence outranks her dam by 16.1 pounds on the circuit performance basis.

Indi Pauline Surprise 215,037, the second daughter of Indi Pense Surprise, also outranks her dam in performance records with 447 pounds of butterfat produced as a 3-year-old.

Indi Pense Surprise 120,220 has no daughter old enough to have had a reasonable chance that has not made the New Salem Circuit standard, which is far more severe as a test performance than the Holstein-Friesian Advanced Registry requirement.

Another cow on the breeding circuit is outstanding in the performance records of her granddaughter, which are as follows:

Dam......Apr. 23, 1904 Sally Dekol Ormsby 75,966 **3.4**	Sept. 12, 1907 Sally Dakota Ormsby 107,485	50.9	Jan. 1, 1911 Dora Dakota Ormsby 162,467	**10.1**
			Dec. 6, 1911 Sally Dakota Ormsby 2nd 190,619	**17.4**
	Aug. 8, 1908 Rose Dakota Ormsby 119,975	61.7	Jan. 6, 1910 Dakota Gem Dekol 164,769	2.2
			June 24, 1911 Dakota of Stillwater 162,467	**10.1**
			June 1, 1913 Stillwater Ormsby Dakota 226,033	**32.1**
	Aug. 4, 1910 Canary Dakota Ormsby 162,465	37.9	April 10, 1912 Canary Stillwater Ormsby 192,044	**50.5**
			Canary Dakota Ormsby 242,362	**50.5**
	June 17, 1911 Dakota Dekol Ormsby 162,466	38.3	June 1, 1913 Stillwater Dekol Ormsby 226,032	2.3

The daughters of Sally Dekol Ormsby 75,996 have not made an extra good showing, but five of her grand-daughters are in the list, while two others fall less than three pounds short of it. This cow is but one of a number on the circuit which have shown good performance for Ormsby blood lines.

Eight years' records on a cattle-breeding experiment are not adequate to measure the hereditary strength of individuals and their blood lines. I have tabulated the occurrence of the Holstein sires in the pedigrees of the better performing cows of the circuit, and find that the three ranking ones carry the same blood lines. The bull Sir Ormsby Hengerveld Dekol 31,212 is the sire of Sir Ormsby Hengerveld Dekol 2nd 41,084 and of Hengerveld Ormsby Dekol 41,085. The sire 31,212 is represented 17 times in the pedigrees of the better producing cows of the Circuit.

Gem Pietertje Paul Dekol 27,282 appears 12 times in the pedigrees of producing females on the circuit. Pietertje and Dekol blood ranks high among Holstein cattle, but the Plains cows from that line of blood are not outstanding. Sir Ormsby Hengerveld

Dekol 31,212 is a twin with Sir Hengerveld Dekol Ormsby 31,211, but has far surpassed him as a sire. Following is their A. R. O. record up to May, 1915, the latest record which I have at hand.

Twins

Sir Hengerveld Ormsby 31,211 .... **23-2-6**

Gem Pietertje Hengerveld Paul Dekol 2,330 .... **13-15-8**

Pietertje Hengerveld Paul Dekol **16-29-14**

Dekol's 2nd, Paul Dekol 20,755 **45-37-34**

Pietertje Hengerveld 24,137 **2-3-2**

Maplecroft Gem 35,909 ..... **3-1-4**

Sir Ormsby Hengerveld Dekol 31,212 .... **63-14-24**

Duchess Ormsby 2nd 35,439 **3-2-3**

The first figure in boldface is the number of A. R. O. daughters.
The second figure in boldface is the number of sons sires of A. R. O. daughters.
The third figure in boldface is the number of A. R. O. grand-daughters.

RANKING A. R. O. BULLS — Vol. 26, 1915

King of the Pontiacs 39,037 .... **149-76-30**
Lord Netherland Dekol 22,187 .... **122-34-133**
7 Sires had more than **100-34-30**
155,860 bulls recorded to May 1, 1915.
278,175 cows recorded to May 1, 1915.
Advanced Registry on May 1, 1915:
2,691 bulls.
37,077 cows.

Whether particular potency starts with 31,212 or whether he has been mated with better females is a matter of conjecture largely. I have inserted the record of the two ranking sires and have also indicated the number with more than one-hundred performing daughters. I have also listed the number of Holsteins of both sexes registered at that time as items possibly not familiar to some of our members.

While this trial is not yet of long standing it is certainly showing marked progress in the average performance records and it is sorting out strains of blood adapted to the rather harsh Plains conditions which it is necessary to cope with to make a success of dairying on the prairie.

Utilizing Soil Potash by Means of Intermediary Crops

A. W. Blair

New Jersey Agricultural Experiment Station

The rather sudden cutting off of America's supply of potash salts as a result of the war, has led chemists and agricultural investigators to consider domestic sources which have hitherto been largely overlooked.

As a result of extended investigations carried on during the past three or four years, a number of materials have been found which, with proper treatment, yield soluble potash salts either directly or as by-products in the preparation of other substances.

But with all that has been accomplished thus far along this line the present output is probably not over one-fourth of our pre-war consumption and the price is still far in excess of what the farmer can afford to pay, except in the case of special crops, or at times of abnormally high prices.

That this is so may prove a blessing in disguise, for undoubtedly we had come to depend too much on *outside sources* to the neglect of our *natural resources.*

To use wisely available natural resources which will help in the development of a country, should be the first thought of any people, and if the present potash situation results in turning the attention of the farmer and agricultural investigator to a better use of the natural soil potash and to the recovery of by-products and waste materials which contain this fertilizing constituent, good will have come from what at first appeared to be a rather distressing situation.

From a very large mass of analytical data it is now well known that the soils of the United States, with the exception of the sandier portions of the Coastal Plains region, and some other limited areas where there is much sand, are well supplied with potash in the form of mineral materials. In many sections as much as 2½ to 3 per cent of potash has been reported, which is equivalent to 25 to 30 tons for the plowed acre. Two samples of Hagerstown loam recently analyzed at the New Jersey Station showed about 6 per cent, equivalent to 60 tons for the plowed acre. Such potash is usually assumed to be slowly available or unavailable so far as the growing

crop is concerned, and acting on this assumption many farmers, under normal crop conditions, use more or less of the commercial potash salts on such soils.

It is indeed true that only a very small fraction of the total amount of this potash is soluble in water at any one time, and it is fortunate that this is so, for otherwise it would be dissolved by percolating waters and much of it carried into the sea.

Knowing that the soil does thus contain a large reserve of slowly available potash, the questions that come at once to the farmer and the soil investigator are: Assuming that other factors are favorable, does enough of this reserve become available each year for a maximum crop? And can anything be done to make more of it available during a given period?

The luxurient growth of trees and other native vegetation frequently found on these soils, and the excellent crop yields, which are often secured without the use of potash, when such lands are cultivated, might lead one to give an affirmative answer to the first question, at once. Such an answer, however, would not be entirely safe without a further consideration of the matter.

Analyses have shown that most crops, and especially those generally spoken of as general farm crops, remove less than 50 pounds of potash from an acre, and it would seem reasonable that under natural weathering agencies such a small fraction of the total amount present might easily become available in the course of the year.

It was while studying the availability of the potash in greensand marl (Glauconite) that the writer was lead to suggest that some crops might use the slowly available soil potash to better advantage than others, and that these crops might be used for turning over or making available this potash, for crops that do not readily utilize it.

The results herewith reported indicate that some crops do utilize comparatively large amounts of soil potash quite readily.

The work was carried out by means of pot experiments with a loam and sandy loam soil. The former was the soil designated as the Penn loam and contained 3.77 per cent of potash, and the latter the Sassafras sandy loam which contained 1.17 per cent of potash.

These soils were taken from out-of-the-way places and it is certain that lime and fertilizers had not been used on them for a number of years, and perhaps not at all.

Earthenware pots holding 16 pounds of the air-dry soil were used and before planting the seed, 10 gm. of finely ground limestone and 4 gm. of acid phosphate were intimately mixed with it. For non-leguminous crops 2 gm. of ammonium sulfate also was added. For leguminous crops the soil was inoculated but no nitrogenous fertilizer was added. The crops grown were rape, Canada field peas, barley, buckwheat and soybeans. For each crop two pots were prepared as above without potash fertilizer and two were prepared with 2 gm. of potassium sulfate. During the growing period water was added from time to time so that the moisture content was kept as nearly at the optimum point as possible.

When the crops were mature or had advanced well toward maturity they were harvested, dried and weighed and potash determinations run on all samples from the Sassafras sandy loam and on a part of the samples from the Penn loam.

The dry weights obtained, together with the percentages of potash, so far as determined, are set forth in table 1.

TABLE 1

Percentage of Dry Matter and Potash (K_2O) in Crops Grown on Two Types of Soil With and Without Potash Fertilizers

Crops		Penn Loam Witho't Potash		Penn Loam With Potash		Sassafras Sandy Loam Witho't Potash		Sassafras Sandy Loam With Potash	
		Dry Matter	K_2O	Dry Matter	K_2O	Dry Matter	K_2O	Dry Matter	K_2O
		gm.	per ct.	gm.	per ct.	gm.	per ct.	gm.	per ct.
Barley	1	43.0	....	44.7	....	60.6	2.89	61.3	3.69
	2	42.0	....	49.4	....	61.6	2.94	58.1	3.76
Buckwheat	1	....	....	....	....	26.9	2.85	40.5	3.32
	2	....	....	....	....	32.9	2.94	30.8	3.02
Canada Field Peas	1	19.6	2.92	23.1	3.13	13.8	5.28	20.3	4.85
	2	16.7	2.76	20.9	3.95	16.2	4.85	17.0	5.66
Rape	1	26.4	3.46	28.2	3.90	37.1	5.10	36.2	5.14
	2	23.5	3.95	....	....	39.0	4.77	35.8	4.49
Soybeans	1	19.9	....	16.1	....	34.6	1.57	24.5	2.05
(Pods well formed)	2	19.4	....	19.3	....	30.4	1.65	25.6	1.83
Average		26.3	3.27	28.8	3.66	35.3	3.48	35.0	3.78

Attention may first be called to the fact that the dry weights of these crops grown without potash are, with slight exception, essentially the same as when grown with potassium sulfate, and this is true of both types of soil.

The average dry weight for all crops without potash on the Penn loam was 26.3 gm. and the average for all with potash 28.8 gm. On the Sassafras sandy loam the average for all without potash was 35.30 gm. and for all with potassium sulfate 35 gm. It is of interest to note that on this soil the pots without potash treatment gave slightly higher average yields than those that received the potassium sulfate.

It thus appears that for these crops and the conditions under which they were grown there was sufficient available potash in the soil for maximum crops even though some of these show unusually high percentages of potash in the dry matter.

The high percentage of potash in the dry matter of crops grown on the sandy loam is especially noteworthy. The Canada field peas gave an average of 4.93 per cent of potash without potash treatment and 4.81 per cent with potassium sulfate.

The barley and buckwheat without potash treatment each gave an average of nearly 3 per cent of potash, and more than 3 per cent where potassium sulfate was used.

The average percentage of potash on this soil for the five crops was 3.48 per cent without potash treatment, and 3.78 per cent with potassium sulfate.

On Penn loam the rape and Canada field peas gave an average of 3.27 per cent of potash without potash fertilizer, and 3.66 per cent with potassium sulfate.

From the foregoing table it is shown that the potassium sulfate did raise the percentage of potash in the dry matter of some of the crops, notably the soybeans and barley, but there is not a corresponding increase in yield of dry matter. This is in accord with results already reported* where it was found that soybeans grown in pots yielded slightly more dry matter (and practically as much nitrogen) without potash, and with greensand marl as a source of potash, than with potassium sulfate, but that in the dry matter from the potassium sulfate treated pots there was 3.24 per cent of potash, whereas in that from the other pots there was an average of 1.7 per cent potash—only a little more than half as much as was found in dry matter from the potassium sulfate pots.

*Greensand marl as a source of potash. Rpt. Dept. Soil Chem. and Bact., N. J. Agr. Exp. Sta., 1917, p. 364.

It appears therefore that soybeans and perhaps some other plants have the habit of storing up an abnormal supply of potash where this is supplied in readily available form. If this "luxury" consumption had been at the expense of the slowly available materials of the soil no fault could be found, but in these cases it was taken from an expensive commercial product, and yielded practically nothing in return. Here, then, are crops that can use rather large amounts of the soil potash when forced to do so, but if permitted, will also use additional commercial potash for which apparently there is no return. Such plants should be more widely used to liberate the locked-up potash of the mineral particles of soils rich in potash.

It is of interest to note that the percentage of potash in rape and Canada field peas grown on Penn loam containing 3.77 per cent of potash, is considerably less than the amount found in these crops when grown on Sassafras sandy loam. This may be due to the fact that in the sandy loam the roots had a greater feeding range, or it may mean that in the Penn loam the potash is held more securely. We may at least conclude that it is not necessarily the soil containing the highest percentage of the slowly soluble mineral constituents that gives up most to the plant, even though it may be the last to become exhausted.

There is still much to be done on the potash content of these and other plants when grown on different types of soil under field conditions. In this connection it may be noted that a sample of rape grown on a loam soil under field conditions gave 4.05 per cent of potash and a sample of Canada field peas grown on similar soil and taken about the blooming stage gave 2.33 per cent of potash.

All the crops mentioned may be easily and quickly grown and with the possible exception of buckwheat may be grown in widely separated sections of the country.

They may be used directly, that is, plowed under as a preparation for succeeding crops; they may be used as pasture for hogs and cattle, in which event the greater portion of the potash would be promptly returned to the soil, or they may be used as hay or forage crops (rape excepted as a hay crop), and in this case, likewise, a good proportion of the potash would be returned to the soil if the manure is properly handled. With only fair handling any of these crops should produce 1½ tons of dry matter

per acre. With such a yield a crop analyzing 3 per cent of potash would turn over 90 pounds of this material which would be ample for corn, wheat, oats, rye, timothy and also for many truck and fruit crops. With a crop analyzing 5 per cent of potash there would be a turnover of 150 pounds, which is about twice the amount required by a 200-bushel crop of potatoes.

Any one of these crops could be grown as a preparation for alfalfa or fall grain. Canada field peas could be grown as a preparation for late corn, and all or nearly all could be grown as a preparation for late truck crops, and in orchards.

It would perhaps be too much to claim that this method of gaining available potash could be widely and generally adopted. In many cases it would not be feasible to take the time to grow such crops as a preparation for the main crop. It is suggested, however, that with care in planning rotations, they might be introduced more frequently than is now the custom. It is certain that one or more of them might be more widely used as hay or forage crops to good advantage. In addition to converting soil potash into an available form they would furnish the much needed organic matter and two of them would also store up atmospheric nitrogen.

The work here reported is only preliminary. It is hoped that when conditions are again normal other crops and other types of soil may be studied in the same way.

The writer acknowledges his indebtedness to Dr. H. C. McLean for the chemical analyses and to Mr. Charles S. Lamson, who resigned his position to enlist in an Ambulance unit, for setting up the pot experiments.

Seasonable Variation in Butterfat Content of Milk in Southern Arizona

R. W. Clothier

United States Department of Agriculture

Authorities on dairying practically all agree that no change of economic value can be made in the amount of butterfat in milk by changing rations or varying methods of feeding; and that the richness of milk with respect to fat is due to hereditary qualities in the cow which cannot be permanently changed by methods of feeding.

Only two of these authorities will be quoted at present, and further on reference will be made to the experimental data upon which such conclusions are based. Henry[1] says, "We have now come to know that the milk of each cow possesses a fixed composition and that normally the richness of milk is not the immediate sequence of feed and care, provided the cow receives sufficient nutriment to maintain her body weight. Cows starved or greatly underfed may produce milk somewhat lower in fat percentage than normal." Eckles and Warren[2] say, "While it is possible under certain conditions to make a variation of a possible 0.2 to 0.4 per cent by giving certain feeds, it is only under conditions so abnormal that it is of scientific interest only and has no practical bearing. As far as the ordinary practice is concerned the feed has no influence upon the richness of milk. The richness of cow's milk is fixed by heredity and cannot be permanently changed by any means. It is a well known fact, however, that a cow in a high state of flesh at time of calving gives richer milk for a short time than does one thin in flesh."

But notwithstanding the writings of scientific men there is still a strong opinion prevailing among many farmers that different feeds do affect the butterfat content of milk, and when a uniform opinion is met with among farmers in a community of any considerable size, the survey method of study usually reveals some basis of fact upon which the opinion rests.

In the study of nearly 900 farms in southern Arizona by the

[1]Henry, Feeds and Feeding, 17th edition, p. 349-50.
[2]Eckles and Warren, Dairy Farming, p. 176.

survey method the farmers were found to be practically uniform in the statement that in the spring and summer months when alfalfa pasture is most abundant, the butterfat test reported by the creameries that buy their milk is much lower than it is in winter months when the cows are fed chiefly upon alfalfa hay. When the creamery operators were consulted upon the subject they were uniform in confirming the statement made by the farmers.

Since in this region there is no regular time or period for the calving of cows, but on the contrary an almost uniform percentage of young calves may be found in all herds at all seasons of the year, it was believed by both farmers and creamery operators that the observed difference in butterfat content could not be attributed to difference in lactation periods of the cows and it was therefore attributed to the difference in the nature of the feed consumed in the two different seasons of the year.

It may be stated here that the feeding practice found in southern Arizona differs from that found in any other section of the United States, except portions of New Mexico and southern California. No grain whatever, except in isolated cases, is fed to dairy cows at any season of the year, and none was fed to any of the cows reported upon in this paper. No silage has been fed up to within the last two years and only 32 cows out of over 500 individuals reported upon in this paper received silage at any time during the year they were tested. None of the herds from which creamery records were obtained were fed silage during the year of records.

The most universal practice followed is to feed cows exclusively upon alfalfa hay and barley pasture during the winter months and upon alfalfa pasture during the summer months. The barley pasture is obtained by seeding barley in the alfalfa fields, and by pasturing grain fields. Pasturing of the alfalfa fields begins in March but the cows are seldom allowed in the fields until the alfalfa is 12 inches or more high and the usual practice is to wait until it is budding for bloom or just coming into bloom before the cows are turned in upon it. A constant supply of summer pasture is obtained by a system of rotation pasturing described by the writer in Circular 54, Office of the Secretary, U. S. Department of Agriculture.

Stable feeding is unknown. When the cows are on the hay ration they are either kept in unsheltered corrals or allowed to

run at will over the Alfalfa fields, picking such green feed as may be obtained at that season of the year from the alfalfa and growing barley, in case barley had been seeded. Winter feeding usually begins in December and ends in the latter part of February, but on account of a somewhat colder winter than usual the feeding of hay may have begun in many cases in October or November, 1916, and extended into March, 1917, the year in which the data for this paper were obtained.

Since the different feeding practices for the two seasons are practically uniform among dairy farmers in this region it was believed that individual records of a large number of cows extending throughout the year, together with records of creamery tests for the same year, would settle definitely the effect of the different practices upon the butterfat content of milk, at least for the year in which the records were kept.

TABLE 1

Creamery Records from 285 Herds Showing the Amount of Milk Delivered and the Butterfat Test for Every Month in the Year

Month	Average Milk Delivered	Average Butterfat Test
	pounds	per cent
July	7380	3.55
August	7115	3.62
September	6065	3.66
October	5969	3.90
November	5890	3.97
December	5431	4.08
January	4934	4.11
February	5368	3.75
March	7423	3.53
April	7618	3.54
May	7861	3.57
June	7726	3.56

Creamery records were obtained from the books of the Pacific Creamery which were kindly made available to the writer by the manager of the company. The main business of this creamery is the manufacture of condensed milk. It was therefore possible to obtain the records of 285 herds averaging about 15 cows per herd from which whole milk was delivered to the creamery throughout the year. A sample of the mixed milk from each herd was taken every day and preserved for a composite test made every two weeks. Records of the amount of milk delivered from each herd also were obtained. The average of these records for each month in the year is shown in table 1.

These records fully corroborate the opinion previously referred to expressed by farmers and creamery men regarding seasonal variation in the butterfat content of milk. Furthermore, they show that the variation is of considerable extent and continues over a considerable period of time, comparatively high tests occurring from October to February, inclusive, and lower tests pre-

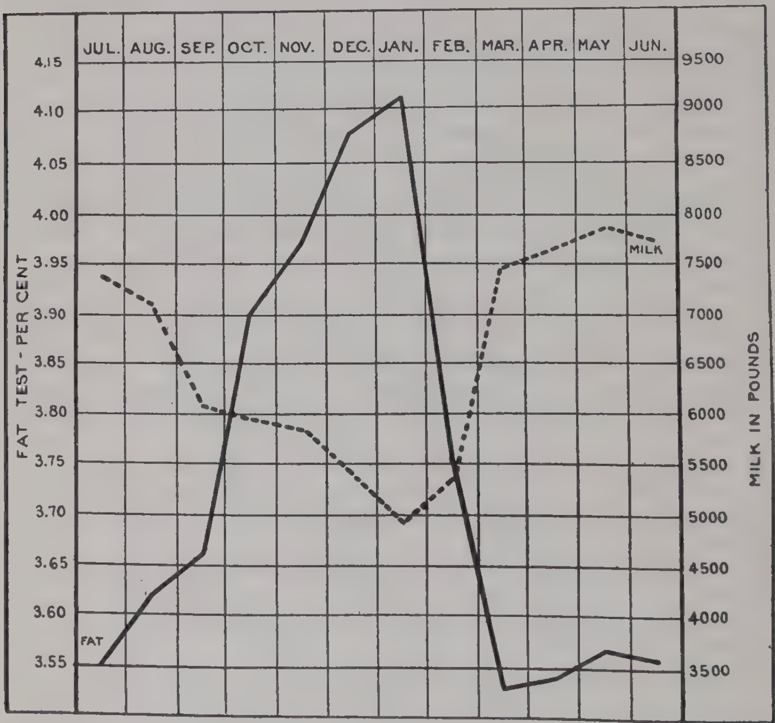

Fig. 1. Diagram showing creamery records of 285 herds for one year

vailing the balance of the year. The high tests reach their maximum in January with rapid falling off in the following month of February. It may be stated here that in February, 1917, most of the barley pasture of the winter season became available, the preceding months having been cooler than usual, resulting in a very slow growth of the barley. For the same reason most of the feed for the month of January was alfalfa hay. In other studies being conducted during the winter of 1916-1917 about one-hundred

dairy farmers were asked to state when they began feeding hay and when hay feeding ended. Many of them began feeding hay in October, practically all were feeding it almost exclusively in January, and all had their cows on pasture in March, but a few continued to feed some hay to prevent bloat; and it may be said that a few farmers in this region feed hay during every month in the year as a preventative of bloat. For all practical purposes of discussion, however, the high tests in table 1 correspond with the period of feeding hay.

TABLE 2

Average Test of Cows in 30 Herds Enrolled in Testing Associations in Salt River Valley, Arizona, for Each Month in the Year

Month	Number of Cows	Average Test	Notes on Stage of Lactation Period		
			No. Cows in Last Month	No. Cows in Last Month but One	No. Cows in Last Month but Two
		per cent			
May	130	3.88	9	13	17
June	324	3.78	26	34	44
July	367	3.87	40	49	40
August	393	3.83	55	50	43
September ..	402	3.82	51	43	43
October	403	3.94	49	43	16
November ...	423	3.92	43	16	5
December ...	450	4.01	16	5	1
January	502	4.09	5	1	8
February ...	537	3.94	1	8	..
March	548	3.78	8	..	..
April	519	3.70	..	..	..
May	201	3.64	..	..	..

Records of individual cows for the same year were made possible by the organization of two cow-testing associations late in the spring of 1916 by the farmers in cooperation with the Extension Service of the University of Arizona and the Dairy Division of the Bureau of Animal Industry, United States Department of Agriculture.

The first cows in these associations were tested in May, 1916, and other cows were entered during succeeding months. The testing was done by two graduates of the University of Arizona who were well qualified for the work and the usual custom of testing night and morning once each month was followed. The records

for the first year of the associations were made available to the writer through the courtesy of Mr. W. A. Barr, then agricultural agent for Maricopa County, Arizona, and now state dairy commissioner of Arizona.

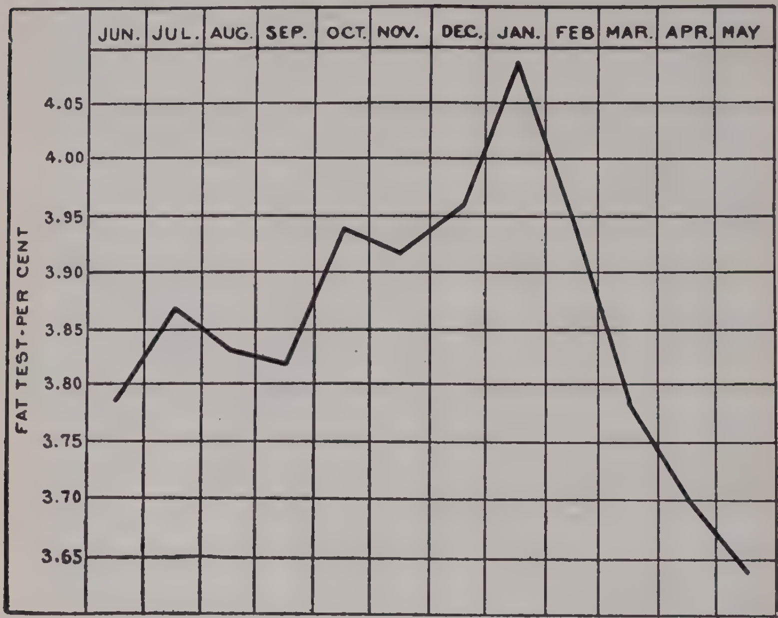

Fig. 2. Diagram showing average test of cows in thirty herds in testing associations in Salt River Valley, Arizona (table 2)

Over six hundred cows were tested in the two associations but some discrimination was made in selecting records for study, the attempt being made to eliminate all or nearly all cows that were in the last month of their period of lactation during December or January, the two high-testing months, this elimination being made to remove one factor other than feed which is known to raise the butterfat content of milk. It is a well established fact that cows test considerably higher during the last month of their lactation period than they do during the middle months of the period. The average test of the cows in both associations, after these eliminations were made, is shown for each of the twelve months in table 2. For this preliminary study the amount of milk produced by the cows was not noted.

It is not known just how many of the cows were in their last month of lactation in April and May, 1917, since not all the records of the cows tested in April were available for their test in May, and none of the June tests for cows tested in May were available. The number of months they had been in milk, however, is known for a large number of the cows and is presented in table 5.

Although there is a much larger percentage of the cows in the latter stages of their lactation periods during the summer months, the test rises steadily to January and then falls off rapidly to May.

TABLE 3

Average Milk Yield and Butterfat Test of 443 Cows Tested in both January and the following April

Month	Number of Cows in Test	Average Milk Yield	Average Butterfat Test
		pounds	per cent
August	278	667	3.78
September	312	670	3.83
October	351	740	3.84
November	393	710	3.86
December	443	636	3.97
January	443	584	4.07
February	443	551	3.98
March	443	614	3.80
April	443	590	3.77
May	167	572	3.85

There was also a much larger percentage of fresh cows during the winter months, the figures for November, December and January being 50, 59 and 61, respectively, compared with 18, 26 and 31 for the months of August, September and October, respectively, and 37, 16 and 4 for the months of February, March and April following.

It is known that cows test higher during the first month of the lactation period than they do in the second and third, and the large number of fresh cows in January may have had a slight tendency to raise the test for that month, though this tendency should have been more than compensated for by the larger number of cows in the second and third months of the lactation period. However, in order to eliminate this factor completely and also in order to compare tests for January and the following April of a large number of the same individual cows, selections were made which eliminated all cows that were not at least in the second

month of their period of lactation in January and which were not also tested in the following April. In this way records of 443 cows were obtained that were tested in both January and the following April, and 167 of these were also tested in the following May. The milk yield of these cows also was obtained. Although in the study of the data presented in the following table comparisons between the tests in January and the months following are more valuable, the data are presented for such cows as were in the test for the months of August to May, inclusive.

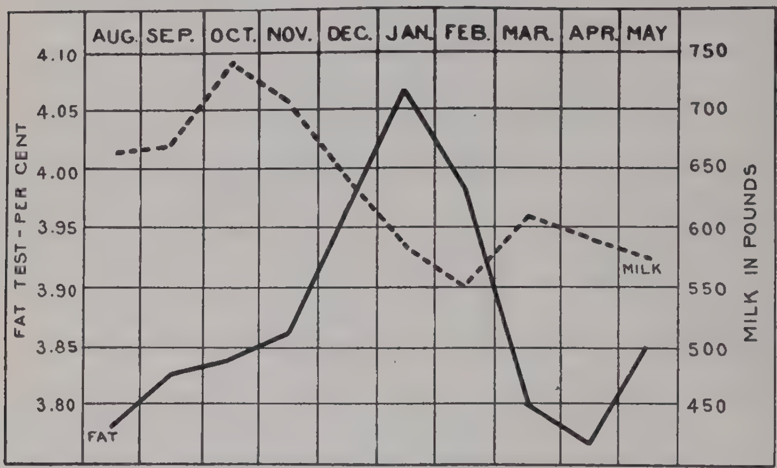

Fig. 3. Diagram showing average milk yield and butterfat test of 443 cows tested in both January and the following April (table 3)

In the selection of the data presented in table 3 the most important factors tending to raise the percentage of fat have been made favorable to the month of April when the cows were on pasture and unfavorable to the month of January when they were on a ration of hay. None of the cows tested in January were in either the first or the last month of their period of lactation, whereas in all probability many of the cows tested in April and May were in the last month, and all of them were three and four months farther along in the period than they were in January. Of the 443 cows tested in both January and April, 135 were in the second and third month of their period of lactation, the two months in which cows always test lowest, when tested in January, while all

of the 443 were in at least the fifth month when tested in April and 175 of them were in the ninth to the twelfth month of their period of lactation in April.

Under these conditions a test of 0.3 per cent lower in April than in January points strongly toward some disturbing factor appearing in April. Moreover, a careful study of the feeding records for the thirty herds revealed the fact that the highest test while the cows were fed hay did not always occur in January, nor the lowest test while they were on pasture in April. Sometimes the lowest test occured in February when the cows were suddenly changed from hay to wheat or barley pasture, and in a few cases the lowest test occurred in May. The highest tests usually occurred in December or January, but in a few cases they occurred in November or February. In 408 cases out of the 443 there was a lower test when the cows changed from hay to pasture and in 29 cases the test was higher. In the other cases there was no change. The cows had been on pasture an average of at least 6 weeks when tested in April.

To determine the extremes of variation between hay feeding and pasture feeding the average highest tests while the cows were being fed hay were compared with the average lowest tests while they were on pasture following the hay ration. This comparison is shown in table 4.

TABLE 4

Comparison of Extremes of Variation in Milk Yield and Butterfat Test of 443 Cows on Changing from Hay Rations to Pasture, in Salt River Valley, Arizona

	Average Milk Yield per Month	Average Butterfat Test	Average Period of Lactation
	pounds	per cent	months
Highest Test on Hay	574	4.27	4.97
Lowest Test on Pasture following Hay Ration....	623	3.53	7.66
Differences	+49	—0.74	+2.69

It will be noticed here that although the cows were 2.69 months farther along in their lactation period, the test while on pasture was 0.74 per cent lower than when the cows received a hay ration which was equivalent to 2.5 pounds less of butterfat when figured on the average monthly production of milk. It is recognized however that the extremes of error is testing may also be present in this table.

It will also be noted that when the cows tested lowest the milk yield was highest. This was true for the average but was not true for all individuals, 267 cows giving less milk when the low test on pasture was obtained than when the high test on the hay ration was secured.

TABLE 5

Effect of Individuality and Advancing Period of Lactation on the Extent of the Reaction to Influences Tending to Lower the Butterfat Content of Milk in April Compared with January

COWS TESTING LOWER IN APRIL THAN IN JANUARY

Lactation Period in January	Number of Cows	January Tests		April Tests		Lactation Period in April
		Avg. Milk Yield	Average Test	Avg. Milk Yield	Average Test	
		pounds	per cent	pounds	per cent	
2	46	659	4.31	688	3.52	5
3	41	668	4.13	659	3.61	6
4	41	686	3.96	713	3.38	7
5	49	585	4.21	592	3.60	8
6	32	533	4.11	527	3.52	9
7	32	455	4.22	481	3.59	10
8 & 9	52	458	4.72	541	3.79	11 & 12
Average of.	293	580	4.26	605	3.58	

COWS TESTING HIGHER IN APRIL THAN IN JANUARY

Lactation Period in January	Number of Cows	January Avg. Milk Yield	January Average Test	April Avg. Milk Yield	April Average Test	Lactation Period in April
2	26	773	3.95	642	4.43	5
3	16	668	3.44	622	4.05	6
4	18	644	3.64	593	3.97	7
5	16	497	3.58	468	4.11	8
6	15	485	3.65	519	4.17	9
7	17	551	3.70	603	4.26	10
8 & 9	22	480	3.75	434	4.36	11 & 12
Average of.	130	596	3.70	557	4.22	

To study this difference further in the individuality of the cows and to determine the bearing of different periods of lactation on the extent of the reaction of the cows to the change from hay to pasture feeding, the 443 cows tested in both January and April were classified into groups based upon advancing period of lactation. Since 293 cows tested lower in April than in January and 130 tested higher, the classification was made in such a way as to separate these two groups from each other. The results are shown in table 5.

Here we have a group of 293 cows dropping in their average butterfat test from 4.26 per cent in January to 3.58 per cent in April, while the average gain in milk yield for April compared with January was only 25 pounds, or less than a pound per day per cow. While all these cows tested lower in April than in January, only 158 of them gave more milk in April than in January, 135 showing a decrease in milk yield as well as a lowering of the percentage of fat.

TABLE 6

The Average Effect of Advancing Stage of Lactation on Change of Butterfat Content in Milk of Cows Changing from a Hay Ration to One of Alfalfa Pasture

Lactation Period in January	Number of Cows	January Tests		April Tests		Differences		Lactation Period in April
		Average Milk Yield	Average Test	Average Milk Yield	Average Test	Milk	Fat	
months		pounds	per cent	pounds	per cent	pounds	per cent	months
2	76	689	4.16	667	5.84	—22	—0.32	5
3	59	669	3.92	648	3.73	—21	—0.19	6
4	63	663	3.86	653	3.45	—10	—0.41	7
5	70	567	4.02	559	3.71	— 8	—0.31	8
6	49	514	3.97	522	3.75	+ 8	—0.22	9
7	49	488	4.04	523	3.82	+35	—0.22	10
8 & 9	77	468	4.40	514	3.56	+46	—0.84	11 & 12
Avg'e of.	443	584	4.07	590	3.77	+ 6	—0.30	

Contrasted with this group of 293 cows which tested an average of 0.68 per cent lower in April than in January, we have a group of 130 cows which tested an average of 0.53 per cent higher in April than in January with an average falling off of the milk yield of 39 pounds per cow for the month of April compared with January. Of these, 56 gave more milk and 74 gave less milk in April than in January. Some of the cows tested in both January and April tested the same in both months and are not included in table 5. Out of the total number of 443 cows, 226 gave more milk and 217 gave less milk in April than in January.

In both groups the difference between the January and April tests is greater with cows in the more advanced stages of lactation, but this is more marked in the group of cows testing lower in April. The average for all the cows grouped on the basis of advancing stage of lactation are shown in table 6.

It has been shown by other investigators that the average butterfat content of milk falls rapidly from the first to the second month of the period of lactation, then falls more slowly to the third or fourth month, with a very slow rise to the eighth month, and then a more

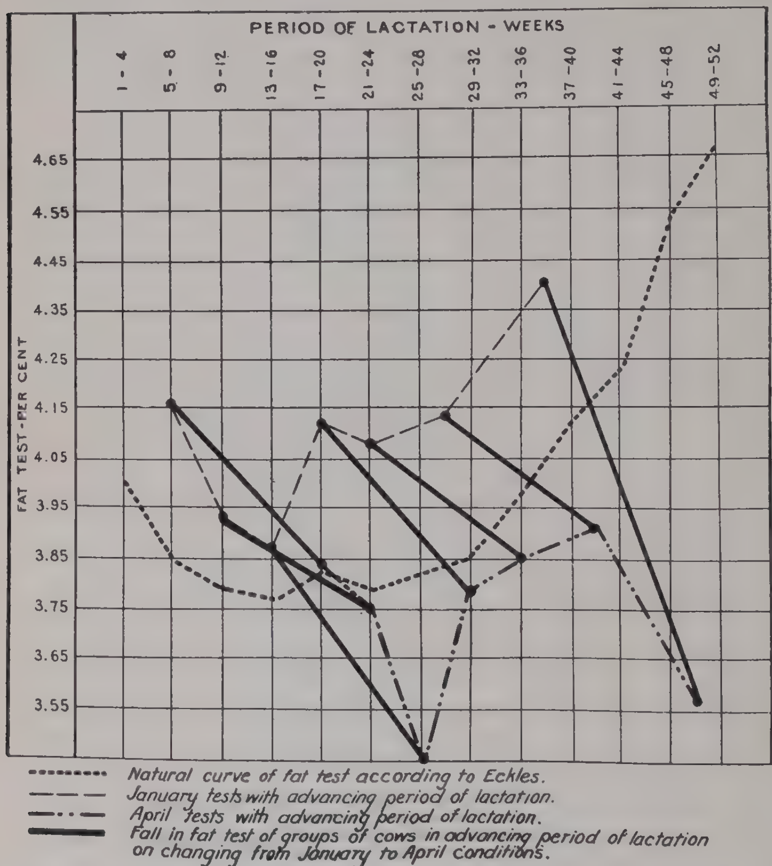

Fig. 4. Diagram showing effect of stage of lactation on percentage of butterfat in milk (tables 6 and 7)

rapid rise to the tenth or eleventh month, with a decidedly sharp rise in the last two months of the period. In studying this subject Eckles fed 11 cows for a period of 12 months on a uniform ration with results shown in table 7[1].

[1]Eckles and Warren, Dairy Farming, p. 175.

It may be noted from table 7 that the average increase in butterfat content for the eleventh and twelfth months over that for the eighth and ninth months is 0.56 per cent. In Arizona, as shown in table 6, a group of 77 cows has had this natural increase overcome, and in addition an average lowering of the fat content amounting to 0.84 per cent has been brought about by changing from conditions prevailing in January to those prevailing in April.

TABLE 7

Effect of Stage of Lactation on the Percentage of Butterfat in Milk when Uniform Rations are Fed

Period	Per Cent of Butterfat
1 to 4 weeks	4.00
5 to 8 weeks	3.85
9 to 12 weeks	3.79
13 to 16 weeks	3.77
17 to 20 weeks	3.82
21 to 24 weeks	3.79
25 to 28 weeks	3.82
29 to 32 weeks	3.85
33 to 36 weeks	3.97
37 to 40 weeks	4.11
41 to 44 weeks	4.42
45 to 48 weeks	4.54
49 to 52 weeks	4.66

The changes in conditions that have taken place are those of feed, temperature and environment.

There is some evidence indicating that daily changes in climatic temperature produce changes in fat content of milk that are inverse to the changes in temperature,[1] but the average of such changes is not great and no evidence has been found by the writer's search of the literature indicating that seasonal changes of temperature affect the butterfat content of milk. The difference in temperature between the months of January and April, 1917, in Salt River Valley, Arizona, was not as great as usual, cool weather prevailing in the spring of 1917, up to the month of June.

In this region the average January climate is similar to the average September climate of New York, Wisconsin, or the New England States, with less violent fluctuations in temperature and almost no

[1]Report Vermont Experiment Station, 1907, p. 189-190.

rain. Under these conditions one would hardly expect the climatic differences between the months of January and April to affect the composition of milk, and this factor becomes of still less probable consequence when viewed in the light of the fact that cows changing from hay in January to pasture in February showed the same difference in the fat content of their milk as has been observed between milk produced in January and that produced in April.

The effect of environment on the composition of milk has not been studied independent of food changes. It has been suggested that the slight rise in fat content noted in Denmark, Iowa, Wisconsin, New Hampshire and Vermont (referred to herein in the review of the literature of the subject) when cows changed from winter feed to pasture, was due to changes in environment rather than to food changes, but there is absolutely no experimental evidence bearing out the suggestion. The changes in environment that took place in Arizona consisted in changing from unsheltered corral feeding to open pasture fields, changes that cannot be considered violent. Furthermore, it is customary in many cases to allow the cows freedom of the fields while they are being fed hay. Under these conditions it does not seem probable that the changes in environment were sufficiently violent to have caused the observed difference in fat content of the milk, though a study of this question with respect to Arizona conditions may well prove worth while.

There is strong evidence in the date herein presented that the fat test and milk yield are to some extent functional of each other, the test rising with a fall in the milk yield and falling with rising milk yield, but in this case the change in milk yield is a direct result of the change in feed.

This functional relation is shown more in the average of all tests, however, than it is in the case of individual cows.

The most probable cause of the difference in fat content of milk in southern Arizona between the winter and summer months seems then to the writer to be the difference in the nature of the feed. The question arises, "if alfalfa hay and alfalfa pasture affect the fat content of milk in Arizona, will other feeds produce similar results?" Meager data bearing upon this question can be ob-

tained among farmers in Arizona at the present time, but with the expansion of the cotton industry now taking place it is quite likely that valuable data respecting the feeding of cottonseed products may soon be obtained.

The writer obtained records from 6 herds that had been fed cottonseed meal. In three cases there was a decided increase in the test, amounting to an average of 0.56 per cent maintained for an average period of 15 weeks with about sixty cows. In another case the feeding was done experimentally with 11 cows divided into three groups, the three rations under comparison being fed simultaneously and the groups being rotated from one ration to another. The cows were fed 28 days on each ration, the milk being weighed and tested daily, with a preliminary feeding period of two weeks on the ration being tested. The rations compared were, (1) alfalfa hay and corn silage, (2) alfalfa hay and cottonseed meal, (3) alfalfa hay, cottonseed meal and corn silage. The rations were fed in such rotation that when the cows received ration 3 eight of them had been 6 weeks on ration 2, that is, the results obtained with ration 3 in so far as affected by eight out of eleven of the cows are the average results over a period of 4 weeks at the end of a period of 12 weeks on cottonseed meal. The test on the three rations was as follows: Alfalfa hay and silage, 2.98 per cent; alfalfa hay and cottonseed meal, 3.48 per cent; alfalfa hay, silage and cottonseed meal, 3.40 per cent. Here is a gain in the test of 0.5 per cent in one case and of 0.42 per cent in another case, seemingly due to cottonseed meal. The total butterfat produced was greatest with ration 2.

In another case a less carefully performed experiment resulted in only slight gains in the percentage of butterfat (0.15 to 0.3 per cent) during a 5-weeks' period in which the amount of cottonseed meal fed varied from ½ to 5 pounds per cow daily.

In one herd out of the six there was no change in the percentage of butterfat where the cows were fed cottonseed meal, alfalfa hay and corn silage with more or less pasture during a period of 12 weeks.

Further details regarding the feeding of cottonseed products in Arizona, as well as conclusions to be drawn from the data herein presented, are reserved for future study.

REVIEW OF LITERATURE

Since the data presented in this paper are contradictory to much of the experimental evidence obtained by investigators of the question and appear to the writer to lead to conclusions at variance with the views held by most writers on the subject, it will be in order here to present a brief review of some of the literature bearing on the subject.

In the review of this literature all experiments with sheep and goats have been eliminated to confine the discussion to dairy cows, and all experiments designed originally to test the effect of food upon the composition of butterfat have also been eliminated, unless the authors or abstractors have brought out the effect on the percentage of fat as well as upon its composition.

Reviews of the literature in a more or less complete form have been published by many authors, among which may be mentioned those by Woll (1), Armsby (2), Atwater and Phelps (3), Hills (4), Anderson (5), Jordan (6), Woods (7) and Allen (8).

The writer has relied upon these reviews for reference and upon abstracts found in the Experiment Station Record, reading the originals of publications issued in this country and some but not all of those issued in foreign countries.

The various experiments may be grouped into five classes as follows:

1. Those testing rations having a narrow vs. a wide nutritive ratio.
2. Those testing the effect of feeding fat on the fat content of the milk.
3. Those testing the effect upon fat content of changing from barn feeding to pasture.
4. Those testing the effect upon fat and water content of increasing the amount of water in the ration.
5. Miscellaneous tests of various feeds in which the effect on fat content has been noted by the authors or in which figures have been given from which the writer has made computations showing this effect.

EXPERIMENTS WITH NARROW VS. WIDE NUTRITIVE RATIO

Kochs and Ramm (9) feeding 9 cows of three different breeds in periods of 4 weeks obtained an increased milk yield with narrow vs. wide rations, but computations made by the writer from tables presented show conflicting results regarding the percentage of fat. The Basal ration consisted of rowen hay, wheat straw and beets, the

protein being varied by means of brewers' grains and peanut cake.

Dean (10) obtained conflicting results with different lots of cows in feeding narrow vs. wide rations in 1891, and therefore concluded that the changes in feed caused no appreciable difference in the per cent of fat or quality of the milk. The feeding periods were of 4 weeks, and there were 3 lots of 2 cows each. The protein was varied by means of cottonseed and linseed meals. Results of experiments along the same line in 1892 failed to show any increase in fat content that could be attributed to changes in feed.

Lindsey (11) experimenting with 6 cows varied the amount of protein fed per day to each cow from 1.3 pounds to 3.76 pounds. The average per cent of fat in the milk when the cows received 1.3 pounds protein daily was 4.16. At the end of 35 days after the amount of daily protein in the ration had been advanced to 2.58 pounds, the fat content of the milk was 4.80 per cent. At the end of 42 days, the daily protein allowance advancing meantime to 2.91 pounds, the percentage of fat had fallen back to 4.45; and at the end of 9 days more, during which the daily protein allowance was increased to 3.76 pounds, the test of five cows had dropped back to 4.33 per cent. The other 3 cows were not in this part of the experiment. The protein was obtained by feeding cottonseed meal and gluten feed against corn meal and wheat bran. In all cases the total nutriments were sufficient for the daily needs of the animals. The roughage was corn ensilage and corn stover.

Lindsey continued experiments designed to determine the effect of feeds on fat content through a long series of years. In 1896 experiments conducted at the Massachusetts (Hatch) (12) Experiment Station in conjunction with Holland and Billings resulted negatively in all cases where 5.83 pounds of gluten meal were substituted for an equal amount of cornmeal. Results in 1901 (13) with two lots of 5 cows each fed in periods of 3, 4, 5 and 6 weeks showed that cottonseed meal with a minimum oil content did not change the fat content of milk, but cottonseed meal and cottonseed oil increased the percentage of fat. In 1908 (14) Lindsey summed up the most important results obtained up to that date, and made the statement that -"different amounts of protein in the daily ration derived from linseed, cottonseed, soybean and gluten meals do not seem to have any pronounced effect in changing the

relative proportions of the several milk ingredients." Experimental data upon which this conclusion was based are as follows: 1, Three pounds of cottonseed meal with minimum oil content (8 per cent) when fed daily to each animal had no noticeable influence on the composition of the milk, but when ⅛ to ¾ pound of cottonseed oil was added the fat content of the milk rose from 5.0 per cent to 5.4 per cent and this increase was maintained for 6 weeks, to the end of the experiment. 2, The substitution of linseed meal with a minimum percentage of oil (3 per cent) for the cottonseed meal depressed the fat content to its normal percentage. 3, Two to three pounds of soybean meal with a minimum oil content (8 per cent) fed daily to each animal did not appear to modify the proportions of the several milk constituents in any way. In 1910 Lindsey (15) in summing up the results of various experiments again stated, "under the usual conditions varying amounts of protein appear to be without influence upon the composition of the milk."

Hayward (16) fed 19 cows in pairs, one on a constant and the other on a varied ration in periods of 40 days. The protein was varied by raising or diminishing the amount of cottonseed and linseed meals fed, these being substituted for corn meal. In summing up experimental work he says, "The nutritive ratio between the limits of 1:3.4 and 1:11.3 had no effect upon the quantity or quality of milk."

Waters and Hess (17) fed 9 cows in 4 periods of 30 days each, beginning about 60 days after they had calved, on varied protein rations. The average fat content of the milk was as follows:

Period 1. Fat 4.09 per cent. Feeds were a grain mixture of gluten meal and chopped wheat, with coarse fodder and corn stover for roughage. Nutritive ratio 1:6.6.

Period 2. Fat 4.74 per cent. Feeds same as in period 1 except that cottonseed meal was substituted for gluten meal. Nutritive ratio 1:3.9.

Period 3. Fat 5.13 per cent. Old process linseed meal substi-instituted for the cottonseed meal. Nutritive ratio 1:4.4.

Period 4. Fat 4.8 per cent. Feeds the same as in period 1.

The average fat content for periods 1 and 4 was 4.48 per cent, and for periods 2 and 3, 4.98 per cent. Here we have an increase of 0.5 per cent maintained for 60 days compared with an average

of two 30-day periods, one preceding the 60-day period and the other following it.

Maerckner and Morgan (18) in three experiments, in which the amount of protein fed was varied by varying the quantities of oil meal and barley meal in the rations, obtained no difference in the composition of the milk with the different rations.

Spier (19) experimented with cows fed on pasturage, brewers' grains, potatoes, bean meal, wheat, cottonseed cake, barley meal, linseed cake, and a variety of mixed rations. His results were published in 1894. His conclusions were as follows: "Although the quantity of milk is easily influenced up to a certain point by the food supplied, the quality is not materially altered by any ordinary mixed feed. The proportion of butterfat is very little influenced by feeds containing a large percentage of oil, such as linseed or cottonseed cake, nor yet by albuminous feeds, such as bean or pea meal, decorticated cottonseed cake, etc." Continuing these experiments to 1897 he says, (20) "Every food when first given seems to have more or less effect in increasing or decreasing the percentage of fat in milk. This effect is, however, transitory and the milk returns to its normal condition about the end of the fifth week."

Hills (21) in 1895 obtained "slightly richer milk" by feeding gluten products against a mixture of bran and cornmeal, but stated that the change was not sufficiently marked to be of pracical importance. His feeding periods were 4 weeks and he states that after this time there was a tendency for the milk to return to the normal.

In 1896 silage from cowpeas and soybeans produced a decided enrichment of the milk, accompanied by a corresponding decrease in the milk yield.

Nine cows fed in periods of 4 weeks showed the increased percentage of fat when atlas gluten meal was substituted for cornmeal, but with 8 other cows, the increase was not maintained when the period was extended to 8 weeks.

In 1897 tests of rations having medium vs. wide nutritive ratios showed no change in the quality of the milk, except when the cows were fed scantily with wide rations, when the fat content was lowered.

In 1900 Hills reported that buckwheat middlings increased the fat content 0.2 per cent, but that the quality of the milk was un-

changed with rations having a medium vs. a wide nutritive ratio. In 1902 and 1903 there were very small variations in composition of the milk due to any of the feeds, very low grain rations slightly lowering the quality, and 9 pounds of grain making slightly better milk than either 4 pounds of 12 pounds.

There was no change in quality of milk when corn oil cake was substituted for wheat bran, and also no change in feeding corn ensilage vs. beets, corn ensilage vs. carrots, or beets vs. carrots. Atlas gluten meal vs. a mixture of cornmeal and wheat bran produced a slight tendency toward richer milk.

Soxhlet (22) decreased the fat content 0.7 per cent by adding large amounts of starch to a hay rotation, but when 4 pounds of rice gluten containing 71 per cent of protein were added to the same hay ration, the fat content was not increased over hay alone.

Whitcher (23) fed two cows in periods of 2 weeks each, substituting 6 pounds of gluten meal for 6 pounds of corn meal and then returning to the original ration. There was practically no increase in fat content with the gluten meal and Whitcher concluded, "Quantity is the result of food influence. Quality is the result of the make-up of the animal."

Cooke (24) fed cream gluten meal against a mixture of corn meal and wheat bran to 9 cows in periods of 4 weeks, alternating the feeds and continuing the experiment 4 months. Only half the corn meal and bran mixture was replaced by gluten meal. In 5 times out of six the gluten meal produced richer milk, the average increase in the fat content being 0.33 per cent.

Bartlett (26) fed 4 cows through 3 periods of 21 days in testing wheat meal against corn meal. He obtained the following results:

Period 1. Wheat meal, milk 1657 pounds; fat 4.39 per cent.
Period 2. Corn meal, milk 1577 pounds; fat 4.52 per cent.
Period 3. Wheat meal, milk 1430 pounds; fat 4.92 per cent.

The cows lost weight in period 2 and gained in period 3. He makes no comment on fat content.

Jordan (25) published results in 1891 of experiments with three rations as follows: (a) cottonseed meal, corn meal, wheat bran; (b) peas and barley; (c) linseed meal, corn meal and wheat bran. He says, "the composition of the milk varied but little and no more, or even less, during the three periods than is often observed when

the ration is not changed." There were 5 cows in each test and feeding periods were 4 weeks.

In 1893 he tested "narrow" rations against "wide" by substituting a mixture of equal parts of gluten meal and cottonseed meal for an equal amount of corn meal, feeding 3 cows in periods of 35 days—alternating the feeds.

Cow 1 decreased the fat content in her milk from 4.70 to 4.24 per cent, and increased again to 4.47 per cent on changing from the mixture of gluten and cottonseed meals to corn meal, and then back to the nitrogenous feeds again.

Cow 2 increased the fat content from 4.07 to 4.77 per cent, and continued the increase to 4.48 per cent on changing from corn meal to the nitrogenous feeds and then back to corn meal again.

Cow 3 increased the fat content from 3.99 to 4.72 per cent, and then decreased to 4.5 per cent with changes in her feed corresponding to those of Cow 1. The average per cent of fat from cows fed corn meal was 4.34 and from gluten and cottonseed meals, 4.73. The total time on each feed was 70 days.

Jordan and Jenter (27) obtained no difference in fat content in feeding timothy hay, corn meal, ground oats and wheat gluten in varied quantities, both in their normal condition and with the fat extracted. In summing up their results they say, "The composition of the milk bore no definite relation to the amount and kind of food." They, with Fuller, obtained similar results later with linseed meal, sugar beets, malt sprouts, ensilage and alfalfa hay (28).

Woll (29) with 14 cows fed through two different winters increased the average fat content of the milk 0.31 per cent by changing from a ration having a nutritive ratio of 1:7.3 to one with a nutritive ratio of 1:6.5. The milk was richer in 11 cases out of fourteen.

In summing up experimental data presented in various publications he concludes, "Differences of a few tenths of one per cent in favor of the more nitrogenous rations may thus, as a general rule, be expected as a result of such a system of feeding."

Cooke and Hills (30) obtained gains in fat content of 0.2 per cent with six cows fed 18 days, and 0.37 per cent with 3 cows during a similar period by adding atlas gluten meal and cream gluten meal, respectively, to a basal ration of hay, corn meal, wheat bran and silage, while in 5 other cases, in which there were from 3 to 7

cows in the experiment, gains made by feeding other corn by-products were insignificant.

G. Kuhn (31) obtained an increase of 0.69 per cent, with two cows in one case and in another case an increase of 0.36 per cent, by adding palm nut meal to a basal ration of hay, straw and mangolds. A third cow was not affected by the change in feed. The feeding periods were 21 to 47 days, including preliminary feedings.

Wilson, Curtis, Patrick and Kent (32), by substituting 10 pounds of gluten meal for 12.5 pounds of corn meal and feeding 4 cows in pairs through 3 periods of 21 days and alternating feeds, obtained percentages of fat as follows: Wide nutritive ratio (corn and cob meal) 3.4 per cent; narrow (gluten meal), 3.98 per cent; wide, 3.33 per cent; narrow, 3.92; average gain, 0.59 per cent.

Atwater and Phelps (33) studied dairy cows on farms in Connecticut, for a period of 5 years, including 32 herds in all. The average fat content of the milk from herds of 226 cows fed less than 2 pounds of protein per herd daily (average 1.67 pounds) was 4.7 per cent; while the milk from 16 herds, containing 227 cows, fed more than 2 pounds of protein per herd daily (average 2.32 pounds) tested 4.9 per cent.

Anderson (34) testing rations having nutritive rations of 1:4, 1:6 and 1:9, respectively, obtained a gradual but slight increase in fat content without respect to the kind of rations. There were two feeding periods of 22 weeks each in which 9 cows were fed in lots of three each. The quantity of protein was varied by adding varied amounts of palm nut meal to a ration of corn ensilage, hay and grain.

Graham (35) in testing the effect of varied amounts of water in the ration on fat content substituted 6 pounds of bean meal and 6 pounds of decorticated cotton cake for 6 pounds of corn meal and thereby raised the average fat content from 2.91 to 3.36 per cent, through a period of 8 weeks. Since in this ration the total water consumed was 6 gallons against 10 gallons in the corn meal ration, Graham attributed the difference in fat content to this difference in water in the two rations. There were 5 cows in the test. The experiment was repeated with similar results.

Crowther (36) in trying to improve the poor quality of morning's milk fed 14 cows in four periods from June 7 to September 9, substituting decorticated cottonseed cake for corn meal without noticing

any definite increase in fat content attributable to the cottonseed meal.

Morgen, Bergen and Westhauser (37) added amid extracts from fodder beets and beet chips to a ration low in fat without any effect on the fat content of the milk produced.

Experiments in Denmark by Fjord and Friis, reviewed from time to time by F. W. Woll in the "Experiment Station Record" and elsewhere (38) in cooperation with farmers, and extending over a period of 10 years, during which nearly 2,500 cows have been in the tests, have failed to show any appreciable differences in fat content due to changes in feed. Barley and oats were tested against roots, oil cakes, wheat bran, wheat and molasses feed. Mixed grain and oil cakes were fed against roots and grain; and roots were fed in addition to the regular ration. The experiments extended in each case over two successive winters, involved many and large herds and were carefully planned and executed. Sixteen trained men devoted their whole time to the work and others devoted a part of their time. In no case was the change in feed violent or did the ration depart from what the authors considered a normal ration among the farmers of Denmark.

EXPERIMENTS IN FEEDING FAT

Hills (29) obtained an average gain of 0.33 per cent, with 10 cows by adding cottonseed oil to a grain ration of bran or corn meal and bran which was maintained 4 to 6 weeks. Corn oil and linseed oil also raised the percentage of fat, but the cows quickly returned to normal.

Lindsey (40) raised the average fat content of the milk of 5 cows from 5.0 to 5.4 per cent by adding cottonseed oil to a ration containing cottonseed meal with minimum fat content, the increase being maintained to the end of a period of 6 weeks. The substitution of linseed meal, containing only 8 per cent oil for the cottonseed meal and oil, reduced the fat content to normal. A larger gain was made with linseed oil, but the milk gradually returned to normal in four or five weeks. Corn oil produced smaller gains with return to normal within 2 weeks. Sudden removal of the corn oil depressed the fat content 0.54 per cent with the return to normal within two weeks.

Bartlett (41) obtained a decided increase in fat content by increasing the quantity of digestible fat in the ration, feeding through periods of 4 weeks for each test.

0.36 pounds digestible fat produced milk testing 5.54 per cent fat.
0.86 pounds digestible fat produced milk testing 6.25 per cent fat.
0.55 pounds digestible fat produced milk testing 5.78 per cent fat.

Sohxlet (21) states that he obtained increased percentages of fat in milk by feeding sesame oil, linseed oil and tallow, provided the fats were given in digestible form. They were fed in an emulsion added to the drinking water. The abstractor does not mention the continuance of the experiments longer than 8 days.

Rhodin (42) obtained increased fat in the milk of two cows fed in periods of 4 and 3 weeks by feeding linseed oil emulsified in water, but the milk had returned to normal at the end of the periods.

Albert and Maercker (43), starting with 10 cows giving milk with an average fat content of 3.03 per cent on a basal ration of sugar beets, hay and straw, obtained the following results by changing the rations:

Period	Kind of Ration	Per Cent Fat in Milk
10 days	Normal, by means of rapeseed cake, cottonseed meal and wheat bran added to basal ration	3.21
16 days	Enriched in fat by means of palm nut cake and cocoanut cake	3.52
21 days	Ration poor in fat	3.20
28 days	Ration rich in fat	3.48
16 days	Ration very rich in fat, the amount of fat in ration for previous 28 days being more than double by means of cocoanut cake	3.96
14 days	Ration poor in fat	3.15

There were 5 cows of each of two breeds in the test and every cow reacted positively to the increased quantities of fat. The yield of milk went down under the increased fat rations and the weight of the cows increased.

Beglarian (44) fed fat in the form of emulsified linseed oil and in ground flaxseed and, although there was an average gain in fat content of 0.23 per cent, negative conclusions are drawn both with respect to the emulsified oil and the ground flaxseed.

Hageman (45) obtained no results in 6 feeding periods, extending from December, 1897, to May, 1898, that would indicate any influence of the fat content of the ration upon the fat content of the milk.

Falke (46) fed two cows on a mixture of meadow hay and fat-free rape cake and in different periods of 20 days each added emulsions of sesame, cocoanut and almond oils in the drinking water. In every case the percentage of fat increased and the yield of milk decreased when the oils were given.

Henriques and Nansen (47) fed two cows a basal ration of hay, and extracted linseed meal to which linseed oil in varying quantities was added. One cow sickened and was thrown out at the end of 6 weeks. The other continued in the experiments 23 weeks. As a rule, the addition of oil to the ration increased the percentage of fat in the milk, the gain sometimes being as high as 1 per cent, but after 10 to 15 days the milk returned to normal.

Wood (48) fed palm oil, stearine, cottonseed oil, corn oil, oleo oil, and cocoanut oil in individual tests with 3 different cows. His conclusions were:

1. That the first effect of an increase of fat in a cow's ration is to increase the percentage of fat in her milk.
2. That, with the continuance of such a ration, the tendency is for the milk to return to its normal fat content.
3. That the increase in fat is not due to the oils but to the unnatural character of the ration.
4. That, though almost any unusual feed may disturb for a time the composition of milk, the effect is not continuous.

Wing (49), on hearing a report that a farmer in New York had greatly increased the amount of butter produced from his cows by feeding them tallow, conducted two experiments; one with Holstein cows of medium age, and the other with Holstein heifers, in which he fed tallow, increasing the amount per cow gradually until a daily ration of 2 pounds was given. The percentage of fat was decreased slightly—the cows being fed 4 weeks after reaching the maximum daily tallow ration. His conclusion was that the tallow had no appreciable effect on the fat content of the milk. Five cows were included in each test.

Goessman (0) obtained slightly richer milk with old process linseed meal than with the new process, the former feed containing 5 per cent more fat than the latter.

CHANGING FROM WINTER FEED TO PASTURE

Fleischmann (51) states that in his observations, extending over 10 years in Mecklenburg, the cows showed a considerable increase in fat lasting several weeks in going from winter feed to

summer pasture, a greater amount of digestible nutrients per day being consumed on pasture than when on winter feed; but there was no such increase noticed with 16 pure-bred Dutch cows, observed at Kleinhof Tapiau, when the winter feed contained as great an amount of digestible nutrients as was obtained on the pasture.

Farrington (52) made observations on 6 cows changing from winter feed to pasture and stated that the pasture had little effect on the quality of the milk but increased the quantity.

Dean (53), in comparing pasturage with and without grain against barn feeding, obtained an increase in the percentage of fat with each of 8 cows when turned on pasture and fed only 1 pound of bran per day and also on pasture with green peas and oats without bran; in the latter case the gain was from 3.51 to 3.97 per cent and on increasing the grain ration the per cent of fat was still 3.83 at the end of a period of 8 weeks. When 3 pounds of peas, bran and wheat were added to the daily ration of each cow in addition to the pasturage obtained, the fat content continued to increase in the milk of four of the cows, the average percentage changing from 3.32 to 4.07. It decreased somewhat in the case of three other cows. He repeated the experiment the following year with similar results.

Friis (54) observed over 1961 cows during a period of 10 years. There was a marked increase in fat content on passing from winter feed to pasture, but this had all disappeared at the end of 30 days.

Whitcher (55) refers to a general belief among farmers in New Hampshire that cows give poorer milk upon going from winter feed to pasture. His observations with two cows showed a slight increase in fat content when changed from winter feed to pasture.

Voorhees and Lane (56) refer to the same common belief among farmers in New Jersey as was observed by Whitcher in New Hampshire, and state that in their own experiments there was a temporary decrease in fat content when changing from a dry ration to one more succulent and richer in digestible carbo-hydrates.

Kjaarsgard (57) observed 19 herds averaging 33 cows to the herd. The average fat content of the milk from all the herds while on winter feed was 3.33 per cent. Twenty days after going on pasture, the average fat content was 3.67 per cent; and after the cows had been on pasture 40 days, the average was 3.60 per cent.

Hills (58) referred in 1893 to the belief among farmers in Ver-

mont that the milk of cows is poorer in fat when they go from winter feed to pasture, and in 1902 (59) published results of 8 years' study of the question. Out of 118 cows observed, 41 showed an increase in fat content of their milk in the first two weeks on pasture, which disappeared after 6 weeks on pasture. Thirty-two cows were not affected by the change and 45 cows, studied only one year, showed a change from 4.88 per cent before going on pasture to 5.18 per cent 6 weeks after going on pasture.

In 1899 Dean '60) reported that the average test of the milk of the college herd for 17 days before going on pasture was 3.69 per cent in the morning and 3.8 per cent in the evening. The average for the first 17 days after going on pasture was 4.36 per cent in the morning and 4.47 per cent in the evening.

Arenander (61) analyzed 2,000 samples of milk, delivered at creameries in northern Sweden, and found a general decrease in fat content of milk as the cows passed from pasture to ample stable feeding and then to scanty stable feeding. His results are as follows:

Period	Food	Per Cent of Fat
June to September	Pasture	3.71 to 4.25
October to December	Ample stable feeding	3.32 to 3.52
January to May	Scanty stable feeding	3.20 to 3.30

Richmond (62) analyzed 12,914 samples of milk delivered at a milk depot in London. The average fat content was lowest in May, June and July, and highest in October, November and December.

Cranfield and Taylor (63) analyzed milk of cows before and after removal from poor pasture to a well balanced ration in the stall and found a decreased percentage of fat after the cows went into the stalls.

Brunovsky (64) in the case of one cow observed a decrease in milk flow from 20.3 pounds daily to 16.3 pounds on changing from pasture to stall feeding, while the percentage of fat increased from 3.7 to 4.05.

Smith (65), after observing 25 cows 5 years, stated, "There is little difference in seasons as to the quality of the milk. Milk while the cows are at pasture is neither richer nor poorer on the average than the milk yielded when the cows are on winter feed."

VARYING THE AMOUNT OF WATER IN THE RATION

Turner, Shaw, Norton and Wright (66), after referring to experiments at Brownsville, Texas, showing that feeding prickly pears lowers the percentage of fat in milk, give details of experiments conducted by themselves with 8 cows at Beltsville, Md., in which all the water the cows wanted was tested against 65 to 75 per cent of that amount and in one case still less water. They concluded that their experiments indicate that "rations of varying water content have no effect on the composition of milk." In reviewing the literature on the subject they quote 8 authors obtaining negative results and 3 positive.

Dean (53) in testing feeding grain in slops against dry feeding, observed a slight temporary decrease in fat content when feeding slops, but there was complete recovery within two weeks.

A. B. Graham (35) obtained a considerable increase in fat content on lowering the water content of rations fed, which he believed due to varying the water in the ration; but, since in the ration of lowest water content he also changed from a ration in albuminoids to one rich in nitrogenous substances, his results could not be considered conclusive.

Lauder and Fagan (67) experimented 3 years with 60 dairy Shorthorns, feeding 4 pounds of concentrates, 112 pounds of turnips and 15 pounds of hay against 19 pounds of concentrates, 40 pounds of turnips and 15 pounds of hay. The ration containing the largest quantity of water did not increase the quantity of water in the milk nor decrease the percentage of fat.

Weiser (68) on feeding wet and dried brewers' grains obtained no difference in the fat content of the milk.

Hoffman-Bang (69) replaced various oil cakes with wet brewers' grains without any effect on the composition of the milk.

An editorial review (70) in the "Journal of the Board of Agriculture," London, summarizes conclusions of various investigators tending to show that the feeding of rations containing large amounts of water does not increase the percentage of water in the milk nor reduce the percentage of fat, and presents the view that the specific effect of many foods on the yield and composition of milk is due to stimulative substances present in small quantities.

MISCELLANEOUS EXPERIMENTS WITH VARIOUS FEEDS

Dean (71), feeding the same roughage, compared 1 pound of wheat bran against a mixture of 5 pounds of pea meal, 3 pounds of oatmeal and 2 pounds of barley meal. The per cent of fat in the milk not affected to any great extent.

Fleischman (72) reported observations on 16 cows for one year for another purpose, states that the fact, long believed to be true in practice, that in general it is possible by increasing the food nutrients to make the milk of cows richer in fat absolutely, as well as relatively, would seem to be fully confirmed.

Sebelin (73) fed whale flesh meal to 10 cows along with turnips, cut straw, hay, rape seed meal, linseed meal and malt sprouts, substituting 3.3 pounds of whale flesh meal for the other nitrogenous feeds part of the time. The feeding period was 50 days and there was a check lot of 10 cows. The author concludes that the flesh meal had no effect on the composition of the milk and believes it impossible to change the fat content of milk by means of foods.

Voorhees and Lane (74), on feeding 4 lots of 2 cows each through periods of 5 to 12 days, concluded that "changes in food influence quantity but not composition of milk."

Hansson (75) says it has been proven that certain kinds of foods, such as palm and coprah cakes and the leaves of beets, have a tendency to increase the fat content of milk, while others, such as poppy and German sesame cakes and inferior rice flour, act in the opposite way. Nevertheless, he looks for sure progress to breeding and selection rather than feeding.

Gunther (76), in testing a mixed ration with fodder beets against fodder beets alone, obtained a reduced yield of milk on fodder beets alone, but no change in fat content during a feeding period of 9 days.

Shuttleworth (77) fed two cows from April 2 to July 21, dividing the time into 5 periods, and alternating between abundant and insufficient nourishment. The variations in fat content were so little as to come within the limits of experimental error. The rations compared were straw, oats and turnips against hay, oats, peas, bran, oil cake and turnips.

Ramm and Winthrop (78) fed three cows from November 5, 1897, to May 8, 1898, dividing the time into 10 periods of unequal length

and varying the feeds during the different periods. The feeds tested and the average per cent of fat in the milk during the last 5 days of a feeding period averaging 18 days are as follows:

	Per Cent of Fat
Malt sprouts	2.98
Cocoa molasses	3.87
Cocoa molasses with peanut cake	3.44
Linseed cake	2.99
Malt sprouts with linseed cake	2.88
Malt sprouts, linseed cake and molasses distillery refuse	2.79
Corn bran	2.33
Corn bran and linseed cake	2.74
Corn bran and blood molasses	2.99
Malt sprouts 6 months after first feeding	3.11

The extreme difference here is 1.54 per cent, or calculated on the lowest fat content, a difference of 66.1 per cent, in favor of cocoa molasses over corn bran. The feeds were tested in the order named. The authors advance the idea that the favorable effect upon fat content of some of the feeds is due to some specific influence of the feed not attributable to the nutrients it contained.

Von Knieriem (79), in summing up results of experimental feeding by different investigators at the Peterhof Experimental Farm, says that palm nut cake increased not only the milk yield but the fat content as well.

Backhaus (80), in experiments to determine the effect of various foods, condiments and coloring matters on the taste of milk, observed no changes in fat content with either cottonseed meal, palm nut cake or sesame cake.

Collier (81), experimenting with 7 cows of 5 breeds, all in the last stages of their lactation periods, increased the daily ration of silage 50 per cent, reduced the daily ration of hay one-third and substituted cottonseed meal for corn meal. The fat content of the milk increased in the case of three of the cows and decreased in the case of the other four. The average change was from 5.12 per cent to 4.83 per cent. The yield of milk increased 5.5 per cent. The cows averaged one year in lactation.

Gay (82) states that richer and more concentrated food will increase the quality of the milk, but that the individuality of the cow has more influence than the food.

Heinrich (83), comparing cocoanut cake with peanut cake, fed 3 cows in alternating periods of 4 weeks each and milked them 3 times a day. The experimental feeds were added to the same basal ration, 4.4 pounds of peanut cake being fed aganist 11 pounds of cocoanut cake. The cocoanut cake increased the percentage of fat as follows:

	Morning's Milk	Noon's Milk	Night's Milk
	per cent	per cent	per cent
Cow 1	From 3.06 to 3.49	From 4.12 to 5.39	From 3.45 to 4.39
Cow 2	From 2.47 to 3.28	From 3.28 to 4.25	From 2.71 to 3.63
Cow 3	From 2.81 to 3.41	From 3.71 to 5.02	From 3.48 to 4.21

The experiment began June 11. Cow 1 had calved in April, No. 2 in May, and No. 3 had been milking 2 years.

The average increase in fat content for the 3 cows and the 3 milkings was from 3.23 to 4.12 per cent, a gain of 0.89 per cent in the test attributed to the cocoanut cake.

Farrington (84), in observing variations in the milk of a herd for one lactation period, states, "When the feed was decreased the yield of milk was diminished and the per cent of fat and solids in the milk was somewhat increased for a short time," and, "The per cent of solids and fat in a cow's milk are not greatly influenced in one period of lactation by an increase in feed," also, "A gradual increase of the grain fed from 12 to 24 pounds daily per head and the change from stable to pasture feed each increased the yield of milk, but had very little, if any, effect on its quality."

Wood (85) tested clover hay and vetch hay against mixed oat hay, and gluten and cottonseed meals against corn meal, and concluded that, "So long as a cow is fed upon a well-balanced ration, composed of foods agreeable to her taste, the variations in the per cent of fat in her milk are mainly due to other circumstances than the sources from which the nutrients in her ration are derived."

Humphreys and Woll (86), by averaging tests of 26 cows observed from 3 to 5 years and of 14 cows tested 3 years, show a relation between the body weight of cows and the percentage of fat in their milk, the milk being poorer when the cows were gaining weight and richer when they were losing weight. Observations extending to 191 cows showed a difference of 0.3 per cent in

favor of cows of lighter weight, and Woll concludes (87), "Light cows as a rule yield considerably richer milk than heavy cows."

Woll (88), in feeding oats against wheat bran, found no difference in fat content, though the oats produced the most milk.

Armsby (89), in experiments substituting oil meal for wheat bran, obtained no changes in composition of the milk that he could attribute to changes in feed.

Linfield (90), in feeding alfalfa against mixed hay and in varying the daily ration of a mixture of wheat and wheat bran from none to 12 pounds, obtained no appreciable differences in fat content due to changes in feed.

Wing (91) observed the fat content of the milk of 7 cows during one lactation period while they were on a farm and fed as the farmer usually fed his dairy cows. They were then taken to the college farm and fed two years with the college herd. Afterward they were returned to the farm and the fat content of their milk observed through another lactation period. In every case the milk was richer in fat while the cows were fed by the college than while they were fed by the farmer, the differences ranging from 0.10 to 0.41 per cent, the average difference being 0.25 per cent.

Cicarelli (92) added beet chips to a normal ration without affecting the composition of the milk, but when the cows were fed exclusively on the beet chip diet the percentages of protein and fat in the milk were both lowered.

At the Fifth International Dairy Congress, held at Stockholm June 28 to July 1, 1911, conclusions based on reports from Kellner, Boggild and Hanson (93) were in support of the theory that "certain foods exercise an influence upon the quantity of fat in milk in the case of cows having a high milk yield but further work is needed as to the conditions governing such an increase and as to its practical importance."

Thiel (94), using a basal ration of meadow hay beets and peanut meal tested the effect on fat content of barley, oats, rye, corn, wheat bran, rye bran, rice feed meal and maizena. The feeding stuffs were found to exert a specific effect on the amount and chemical composition of milk independent of their nutrient constituents. Maizena, corn and oats decrease the percentage of fat; palm nut cake and cocoanut cake increase it, and poppy-seed cake and

rice-seed cake decrease it. The other feeds did not influence the amount of fat so perceptibly.

Moses, Peter and Kappeli (95) fed 2.2 pounds of sesame meal daily per head without producing any marked variations in fat content.

Von Szankowske (96) concludes that palm nut cake rich in fat exerts a favorable influence upon the fat content of milk, but the addition of oil acts unfavorably except when the oil is present in the feed in its natural state. Rape seed cake had no influence upon the fat content, while peanut cake increased the fat content only at the beginning of the feeding period.

Kirsten (97) made observation on 20 cows changing from poor to good pasture and noticed a large increase in the quantity of the milk yield but no change in its composition.

Marcas and Huyge (98) performed two experiments, one with 15 cows and one with 20 cows in which there was no change in the fat content of the milk that they could attribute to the influence of food. The feeding period was 4 weeks and there was an unusually large number of different feeds in the same experimental ration.

J. S. Moore (99), after conducting several experiments to determine the comparative value of cottonseed meal and cottonseed as feeds for dairy cows, stated that there was no permanent change in the fat content of milk due to the cottonseed products.

SUMMARY

Perhaps a more diligent search of the literature would reveal reports of other experiments bearing on the question, but it is not probable that they would be any more uniform in method or less contradictory in results than those reviewed herein. There are three distinct suggestions found in the reports reviewed as to food factors that might increase or decrease the fat content of milk. These are "narrow" rations, fatty rations, and specific influence of certain feeds, irrespective of their nutrients. There is scarcely an experiment in the list, however, in which two or more of these factors are not combined.

For example, some of the experiments seem to indicate that there is some specific influence in cottonseed, either in the oil or in the nitrogenous compounds, tending to increase fat content of milk,

but many of the rations fed in testing the influence of narrow vs. wide nutritive ratio contained cottonseed products in both the wide and the narrow rations. The same thing is true respecting various other feeds, such as palm nut cake, cocoanut cake and gluten meals. In testing nitrogenous rations, sometimes the quantities of the same feeds have been varied and at other times one nitrogenous feed has been substituted for another. Again, Lindsey's experiments indicated strongly that the specific influence of cottonseed meal and certain other oil-factory by-products is to be found in the oils they contain, rather than the protein compounds; and yet the amount and nature of these oils present have been constantly varied in both rations in nearly all experiments on the nutritive ratio. The same has been true in many of the experiments in feeding fat, while if there is anything in the suggestion of specific influence of foods this disturbing factor has been present in nearly all experiments of all kinds.

All experiments point strongly to the conclusion that the individually of the cow has a great infiuence upon her reaction to changes in feed and upon the length of time such a reaction may continue; also, that different cows react differently to the same changes in feed. This being the case, satisfactory results could be expected only when the number of animals in the experiment is comparatively large. Yet in most of the experiments reviewed the number of cows was very small, rarely going above six or seven and in those few experiments and observations extending to large numbers of cows the changes in feed consisted largely in varying the quantities of the same feeds rather than in complete and violent food changes. Regarding the number of individuals to be used in an experiment Thorne (100) says, "The necessity for dealing with large numbers of individuals in the study of questions pertaining to animal life and nutrition is exemplified in every test under review. It would seem that experiments including two or three individuals only are scarcely worth the making."

The length of the feeding period is also an important question to be considered. The belief of practically all scientists who have studied the question that the fat content of a cow's milk will fluctuate above or below a certain constant fixed by the individuality of the animal seems to be supported by practically all of the experiments reviewed, but the violence of such a fluctuation and the length

of time it can be prolonged seems to depend largely upon the nature of the food, and in the light of the data obtained in Arizona, perhaps also upon the stage of the lactation period. Short feeding periods do not therefore give as reliable results as longer ones. Many of the experiments reviewed herein were not continued long enough to be of practical value.

It is to be noted, however, that many of the experiments showing the most positive changes in butterfat content were continued through periods of 4 to 8 weeks. The longer periods are of sufficient length to be of practical value to farmers, provided a considerable change can be affected without inverse changes in the milk flow, and their value becomes greater if by causing a violent fluctuation in the opposite direction for a short time the change in the positive direction can be repeated for another period of 6 to 8 weeks, as seems to be indicated by the experiments of Ramm and Mintrop (78), A. B. Graham (35), Lindsey (14), Waters and Hess (17) and others reviewed herein. It is recognized, however, that the value to the farmer of producing such changes will also depend upon the cost of the ration and its effect upon the milk flow as well as upon the percentage of fat, and that there is little data indicating that such changes can be produced economically.

That the amount of the change to be produced by a given feed may depend largely upon the stage of the lactation period of the cow is strongly indicated by the data from Arizona, and this is the first comprehensive effort to determine the influence of this factor that has so far come to the notice of the author of this manuscript. Perhaps the neglect to take notice of this factor is responsible for much of the contradictory evidence that has been obtained by experimenters.

There has also been a tendency of investigators to minimize the relative amount of the changes in fat content. There has been almost uniformity in the statement that highly nitrogenous rations produce increased milk yield, but the gains upon which statements are made are often not more than 2 pounds on a daily milk yield of 20 pounds. This is no greater gain proportionately, however, than a gain of 0.3 per cent in fat, yet the same investigator will refer to the one as a direct positive result of food and dismiss the other as being of insignificant consequence or even refer to it as a negative result.

After a careful review of the literature herein referred to, and after a careful study of the vast amount of data obtained in Arizona, it is impossible for the author of this manuscript to believe that the seasonal variations in butterfat content of milk observed in Arizona are not due directly to changes in feed, and this view will be maintained until it is definitely proved that some factor other than food is responsible or these changes. It should be stated, however, that such conclusions are my own, and that they in no way commit the United States Department of Agriculture to their acceptance.

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Some Data on Codling Moth Control in the Grand Junction District in Colorado

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In the early experimental work with arsenical sprays for the control of the codling moth*, when Paris Green and London purple were used, it was found that one or two sprays, thoroughly applied at the correct time, would save about 70 per cent of the fruit that would be wormy if no treatment was given.

Later experiments have given even better results until, in recent years, it is common to see reports of as good as 90 to 95 per cent of worm-free apples as a result of two or three applications of an arsenical poison. Such results make a Colorado entomologist "green with envy," so to speak, for he uses the same materials and is certain he uses just as good methods, and yet in some of the orchard sections of his state, growers seldom get better than 70 or 80 per cent of their apples free from worm injury after 5, 6, or even 7 thorough sprayings. It is the usual thing for the orchardists in the lower Grand Valley in Colorado to make this number of applications for codling moth control. We doubt if there is another apple-growing district in the country where the growers are better equipped with the latest and best power outfits or where more thorough and intelligent spraying is done, and Colorado has very little precipitation to wash the poison from the fruit. Yet, according to our investigations, the average results from the best sprayed orchards are not better than 75 per cent perfect fruit, so far as worm-injuries are concerned. Under "worm injuries" we include all shallow burrows and mere bites through the skin, or "stings," as they are called by some Colorado fruit growers.

By way of proof of what has just been said concerning thorough orchard spraying in the Grand Valley, we give the following rather careful estimates which we made in 1914, concerning the apple orchards in Mesa County:

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*15th Ann. Rpt. State Entomologist of Illinois, 1886, p. 15.
4th Ann. Rpt. New York Agricultural Experiment Station, 1885, p. 218.

Total area of bearing apple orchards, including many that are young, not over 7,000 acres; arsenate of lead paste used against the codling moth, approximately 470,337 pounds for the season; cost of poison, somewhat more that $47,000; cost of application to the trees, counting the depreciation of the machinery used, not less than $88,000; total expense to the orchard growers in spraying their apple orchards to control the codling moth during the summer of 1914, fully $135,000. Most of these orchardists used from 10 to 16 gallons of spray material per full-grown tree at the first, or calyx spray, and about two-thirds of this quantity at each of the later applications.

To illustrate how difficult the problem is that the orchardists have to contend with in the lower Grand Valley in Colorado, we call attention to the following data collected near Grand Junction in 1914 by Mr. Claude Wakeland:

An experimental orchard was divided into blocks that were sprayed, 1, 3, 4, 5, and 7 times, respectively, and counts made giving the following results:

Trees given calyx spray only had 92.83 per cent of their apples worm-injured, of which 1.11 per cent were mere "stings," or shallow punctures.

Trees given calyx and two cover sprays had 62.76 per cent of their apples worm-injured, 18.55 per cent of which were skin punctures only.

Trees given calyx and three cover sprays had 42.61 per cent of their apples worm-injured, of which 22.61 per cent were skin punctures only.

Trees given calyx and four cover sprays had 48.14 per cent of their apples worm-injured, of which 34.44 per cent were skin punctures only.

Trees given calyx and six cover sprays had 35.46 per cent of their apples worm-injured, 24.74 per cent of which were skin punctures only.

Counts of 1000 or more apples in each of several nearby orchards belonging to men who were considered to be thorough in their spraying and in general care of their trees were also made and with the following results:

Trees having calyx and two cover sprays averaged 48.91 per cent worm-injured apples, of which 9.96 per cent were skin punctures only.

Trees having calyx and three cover sprays averaged 34.47 per cent worm-injured apples, of which 14.98 per cent were skin punctures only.

Trees having calyx and four cover sprays averaged 27.34 per cent worm-injured apples, of which 15.42 per cent were skin punctures only.

Trees having calyx and five cover sprays averaged 27.15 per cent worm-injured apples, of which 15.09 per cent were skin punctures only.

Trees having calyx and six cover sprays had 26.32 per cent worm-injured apples, 17.80 per cent of which were mere skin punctures.

We believe these data fairly represent average conditions in the Grand Junction section.

It will be noticed that even where 6 or 7 sprayings were made,

the percentage of worm-injured fruit averaged about 25 per cent of the entire crop. It is also interesting to note that the "stings," or mere skin punctures, regularly increased in proportion to total worm injuries as the number of cover sprays was increased, calyx sprays having no effect to increase them. On unsprayed trees the stings, according to our observations, seldom exceed 3 per cent of the total worm injuries and are commonly lower than this. On trees sprayed 5 to 7 times they often make up fully 50 per cent of the total worm injuries. The explanation seems undoubtedly to be that the little worms become poisoned in a very large percentage of cases before they get deeply into the apples where thorough cover sprays are made, while nearly all enter safely when cover sprays are not applied.

In one of our experimental orchards, where the calyx spray only was used, 92.83 per cent of the apples were worm-injured, of which only 1.11 per cent contained stings only, and of the worm holes, but .16 of 1 per cent were in the blossom end, indicating a very efficient calyx spray. While we consider the calyx spray the most important one of the year, under the extreme infestation prevailing in the district, it seems to be almost useless when applied alone, for there will often be enough side worms to produce later broods in great enough numbers to nearly ruin the crop.

Counts involving 28 of the better-cared-for orchards, and more than a thousand apples from each, having from 3 to 6 cover sprays, averaged 26.12 per cent of worm-injured apples, but with only .167 of 1 per cent of the worm holes in the blossom end. In only one of these orchards did the calyx worms exceed .90 of 1 per cent and in fifteen the examination of 1000 apples did not give a single calyx worm hole. Upon unsprayed trees in the same locality the calyx worms usually amount to between 60 and 70 per cent of the total worm holes. One could hardly ask for better evidence of thorough spraying on the part of the fruit growers.

The severe injuries by the codling moth in portions of Mesa County and the poor success that growers were having in controlling it, led us, in 1914, to plan a series of observations upon the insect's life history, including observations in neglected unsprayed orchards where there would be no control measure to interfere with its normal development, which has given interesting results, some of which are reported below.

LIFE HISTORY DATA

A small orchard of about 200 large trees, fairly well isolated from surrounding orchards, and which had not been sprayed or otherwise properly tended for two years at least, was secured for our investigations in 1914, and Mr. Claude Wakeland was put in immediate charge of collecting the data.

Eleven trees were scraped and banded with burlap. The first worms appeared under the bands on June 13. The bands were removed every morning, the worms under them counted and placed in breeding cages which were kept in the shade and opened each day, and a complete record kept of the worms captured and the moths that emerged from them. After the moths emerged they were returned each day to the orchard in order not to interfere with the normal development of the second brood of worms and moths. The total number of apples borne on these 11 trees was 56,584; total wormy 48,625 (87.48 per cent of the crop); apples free from all worm injuries, 6,959 (12.52 per cent) of the total crop; total worm holes, or worms developing, 67,257, or 121 worms to each 100 apples; total worms taken under bands, 29,175, or 43.5 per cent of the entire number.

Figure 1 is a graph representing the record of larvæ taken under bands in this orchard from June 13 to October 30. Figure 2 is a graph representing the emergence of the moths reared from the worms, and figure 3 is a graph representing the variations in minimum temperatures for the period of the records.

For the best interpretation of these graphs, it is necessary to establish a normal, or expectancy curve, as accurately as possible to represent the rise and fall in numbers that would result from a constant or gently rising temperature. This we have attempted to do in figure 4. The solid black line represents the frequency curve for larval emergence from the apples, as shown in figure 1, and the broken line represents the expected emergence, divided into two broods, or rather, a first brood and a combination of the second and third broods, the last being but partial and not affecting the record until late in September. Line C, indicating egg parasitism will be referred to later.

Concernnig these graphs, we would like especially to call attention, first, to the abrupt rise of the frequency curves in all stages of development after the first appearance of larvæ, moths and eggs;

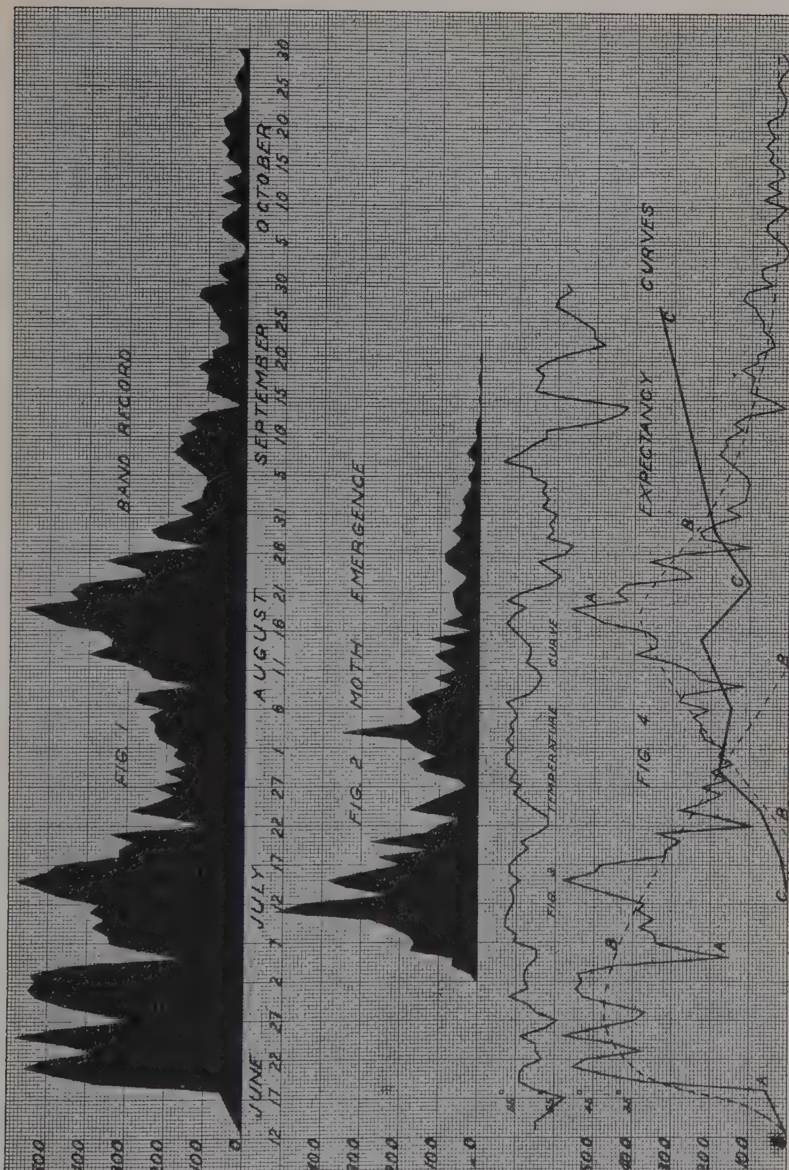

Fig. 1. Graph representing daily collection of codling moth larvæ under bands, Grand Junction, Colorado.

Fig. 2. Emergence of moths from larvæ represented in figure 1.

Fig. 3. Graph of minimum temperatures.

Fig. 4. A, band records; B, normal or expectancy curve for band record; C, record of parisitized eggs.

second, to the over-lapping of the first and second broods in the Grand Junction record (figure 1) and their better separation in the records made for us in 1917 and 1918 by Mr. J. H. Newton near Paonia, Delta County, as shown in figures 5 and 9, and in the most complete separation of the first and second broods of moths and eggs in the Paonia records as shown in graphs at figures 10 and 11 and in the Fort Collins records shown in figures 13 and 14; and third, to the effect of varying temperatures on the activity of this insect in its larval moth and egg stages of development. The graphs shown by figures 3, 7, and 12 give, in each case, the variation in minimum temperatures. As examples, in figures 1 and 2, notice the drops in the frequency curves due to the low temperatures on June 22 and 27, July 4 to 7, and 20 to 24, August 8 to 11, and 26 and 27, and September 13 and 14, etc; in figures 5, 6, and 8, the drops due to low temperatures on July 25 to August 1, August 11, etc., and in figures 9, 10, and 11, on May 31, June 19, August 7, etc.

In general, it may be said that when a low temperature comes on in the early evening, and especially if accompanied by rain, the activity of the codling moth in any of its stages is reduced in proportion to the lowering of the temperature.

In all mountainous districts, where there is little cloudiness and a clear atmosphere, the difference in temperature between the shaded areas and those warmed by the direct rays of the sun is extreme. As a result, codling moth larvæ in places much exposed to the sun's rays develop much earlier than those in shaded situations and the first brood of moths to emerge for egg laying in the spring are continued through a long period of time. When there is added to such weather conditions as these, the tendency to sudden low temperatures, which are also rather common in mountainous districts, retarding the normal progress in insect development as shown in the graphs referred to, we have conditions very favorable to the blending of life periods as shown in figures 1 and 4. The more complete separation of the moth and egg broods as shown in figures 10, 11, 13 and 14 is probably due to the uniform conditions in the breeding cages and the tendency of retarded individuals to speed up.

The Paonia records, with which we are contrasting the Grand Junction data, also were taken in a mountainous section, but the conditions are quite different—the growing season is about 20

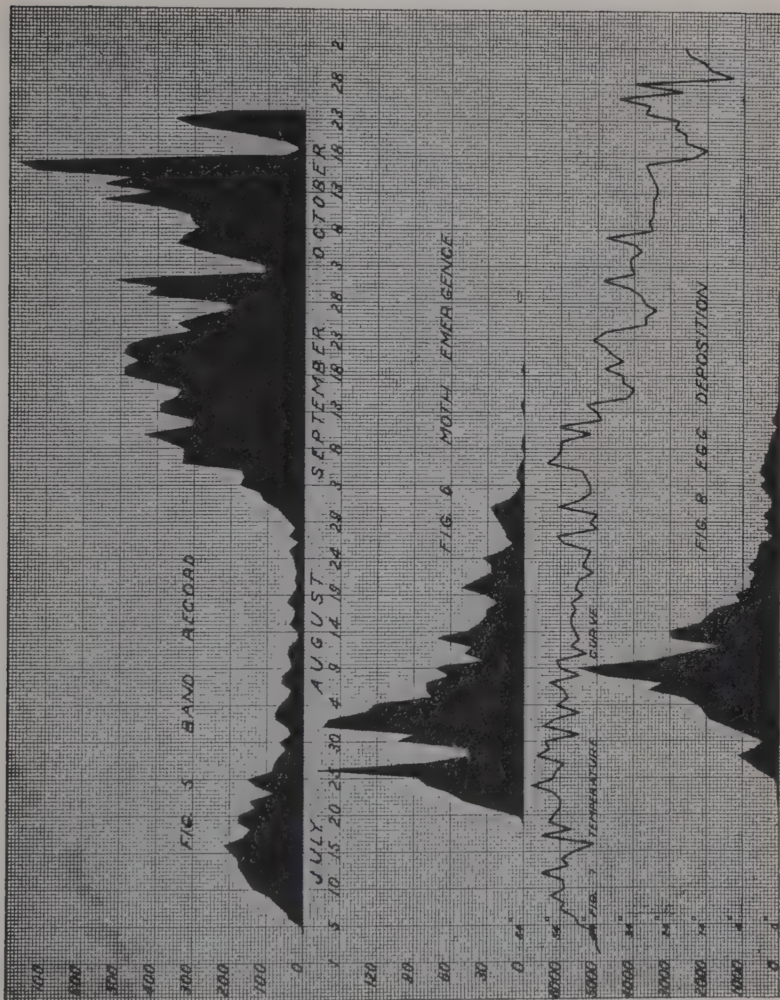

Fig. 5. Daily collection of codling moth larvæ under bands, Paonia, Colorado, 1917.

Fig. 6. Emergence of moths from larvæ represented in figure 5.

Fig. 7. Graph of minimum temperatures.

Fig. 8. Eggs deposited by moths represented by figure 6.

days shorter, the mean temperature lower, and the broods of the codling moth are rather well separated, as shown for the larvæ in figures 5 and 9, and for the moths and eggs in figures 10 and 11. We regret that we do not have egg records for the Grand Junction section to accompany figure 1, but ample records have been made by the Bureau of Entomology and we have not thought it wise to duplicate their work. We are permitted to say that their records are quite in harmony with the statements here made.

It must be evident, other conditions being the same, that it would be easier to control the codling moth by means of sprays where the two broods are well separated, and especially if the broods of eggs are well separated and massed, as such a condition makes it more possible to fix upon the critical periods when sprays may be applied to secure the best results. We should add, too, that our data make it certain that there is commonly a partial third brood at Grand Junction, while in Mr. Newton's two years of breeding-cage records, involving 17,205 moths, 178,495 eggs, and 50,080 larvæ, there was practically no third brood, and less than 25 per cent of a second, in 1918, at Paonia. At Grand Junction on June 13 to 18, 1916, 106 larvæ were taken from bands and placed in breeding cages. From these, 27, or a little better than 25 per cent, transformed into third brood moths between August 10 and September 16, the maximum emergence being August 21. Our records indicate that about the same condition exists at Fort Collins as at Paonia.

These differences in condition seem sufficient to explain why it is necessary at Grand Junction to spray from 5 to 7 times, or every two or three weeks from the time the petals fall until the apples are picked, while under Paonia and Fort Collins conditions one calyx and one or two cover sprays for the first brood of worms and one cover spray rightly timed for the second brood usually give good protection and very clean fruit.

The comparatively small second brood of worms appearing in the unsprayed Grand Junction orchard, as shown in figure 1, needs an explanation, which is easily furnished by line C in figure 4 representing, approximately, the percentage of unhatched eggs of the second and third broods of moths that were found from day to day to be parasitized, and averaging more than 50 per cent during August and September. As a result, the first brood of

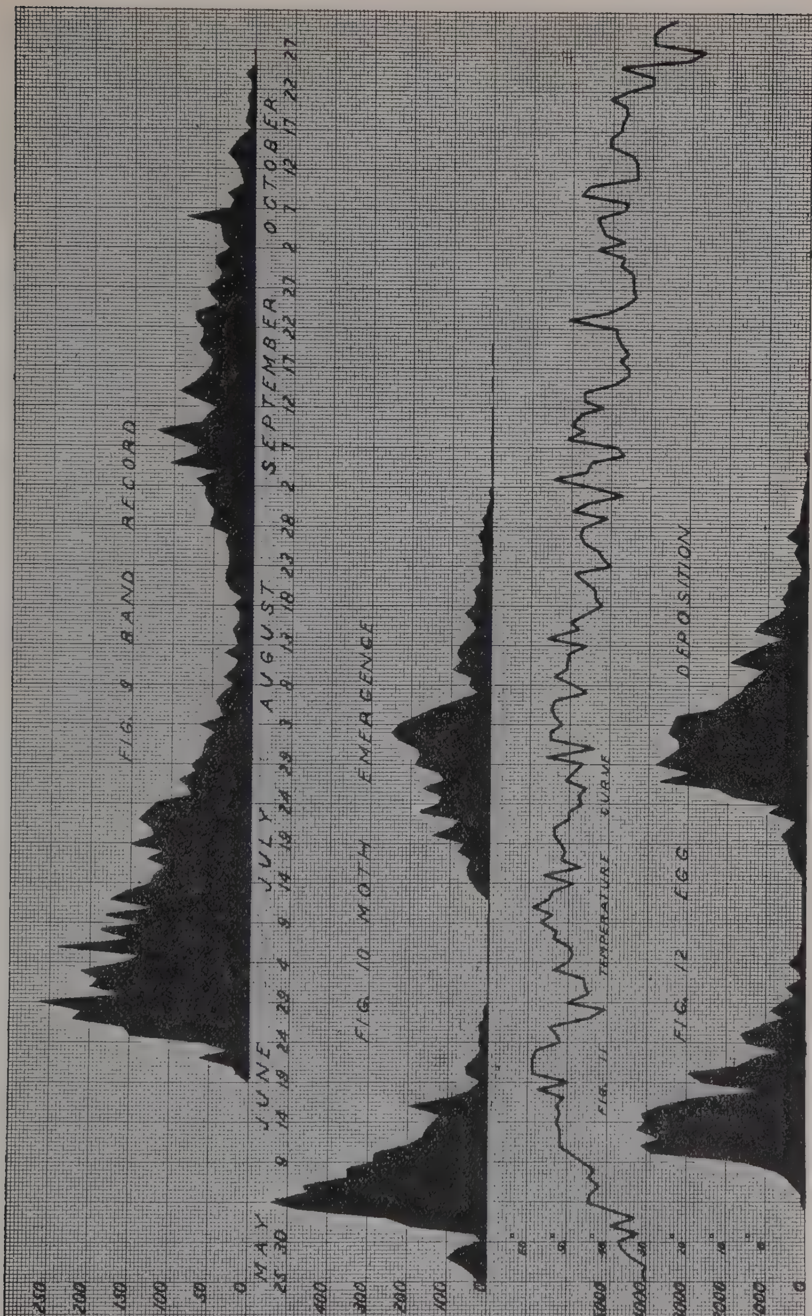

Fig. 9. Daily collection of codling moth larvæ under bands, Paonia, Colorado, 1918.

Fig. 10. Emergence of moths from over-wintering and larvæ represented in figure 9.

Fig. 11. Graph of minimum temperatures.

Fig. 12. Eggs deposited by moths represented by figure 10.

worms very nearly equaled in numbers all that followed. This is not a normal condition in the Valley.

SUMMARY

The following are some of the more important conclusions that we have arrived at from a study of the above data.

The climatic conditions at Grand Junction are very favorable for the development of the codling moth, and especially for carrying a large brood of worms over winter, extending the time of moth emergence so as to cause a considerable overlapping of the first and second broods.

The tendency of the larval broods to overlap is increased by sudden low temperatures, often lasting several days, after the moths of the first spring brood have begun to lay eggs.

There is, normally, a partial, and sometimes a considerable portion of a third brood of the codling moth in the Grand Junction section, which materially increases the number of worms to enter the apples about the last of August and during September.

The failure to get satisfactory control of this insect by spraying is not due to failure in making a good calyx spray in the better cared-for orchards, but to the abundance of the insect and its continuous performance throughout the growing season.

The greatest need of the orchardists in this section is a reliable chart that will show the rise and fall in numbers of larvæ hatching throughout the summer, which would fix the best dates to spray, but this can be satisfactorily accomplished only by a competent entomologist in the field throughout the summer.

The codling moth, under present conditions, can not be well controlled in the lower Grand Valley in Colorado by means of a calyx spray and one or two cover sprays.

Burlap bands, properly applied and attended, are a very important aid and will lessen the late broods by fully 30 to 40 per cent.

Stings, or shallow burrows through the skin of the apple, are nearly all due to worms being poisoned while attempting to enter fruit that has been given a poisonous cover spray.

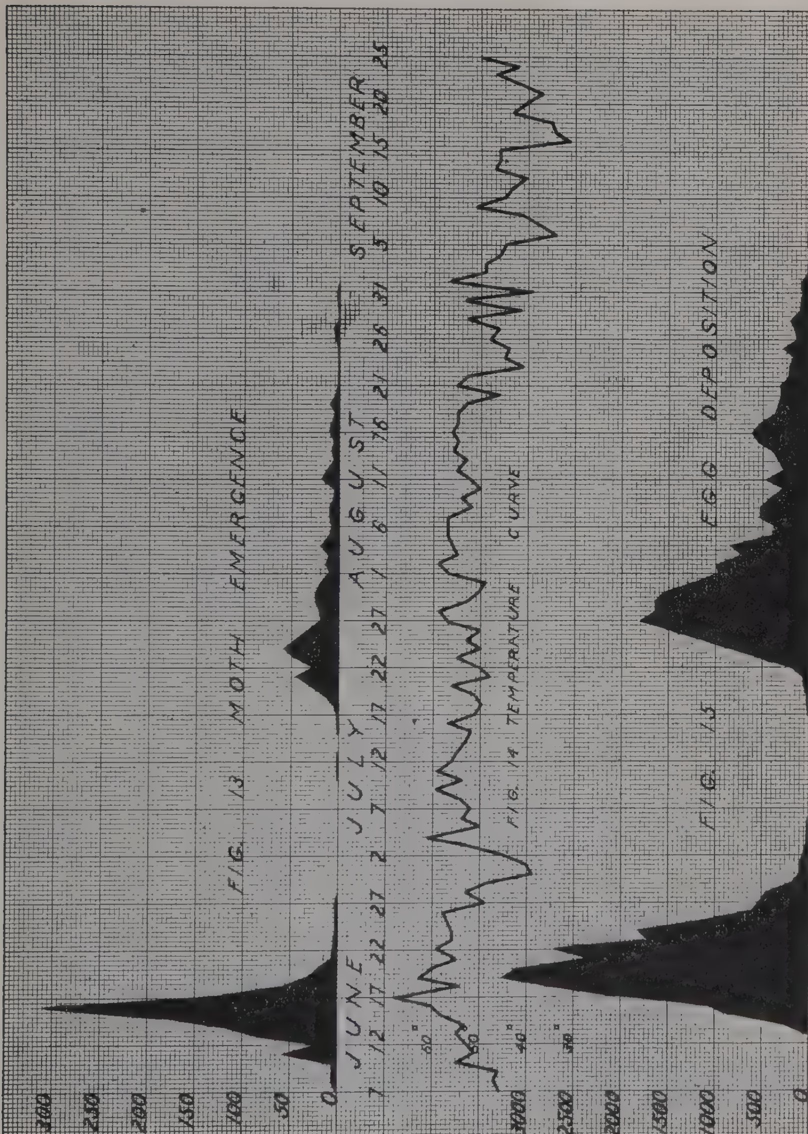

Fig. 13. Moth emergence, Fort Collins, Colorado.
Fig. 14. Graph of minimum temperatures.
Fig. 15. Eggs deposited by moths represented by figure 13.

Lime as a Factor in Maintaining Soil Fertility

I. Rotations Without Legumes

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Men have known, for a very long time, that applications of lime to the soil often result in increased crop yields, and writers on agricultural subjects have frequently referred to the excellent crops and the splendid growth of native vegetation in countries where the soil is of limestone origin.

During the last quarter of a century, the use of lime for improving soils and increasing crop yields has been very widely studied. The agricultural press, students of soil fertility problems, and farmers' institute lecturers, have persistently recommended the use of lime in some of its forms. Frequently, these recommendations have been made for specific conditions or particular crops; but frequently also they have been made on general principles, without any very definite idea as to the cause and effect.

As a result of this persistent agitation, lime, in one or another of its forms, is more widely used today than ever before. In some of the states, laws have been enacted regulating its sale, very much as the sale of commercial fertilizers is regulated.

We now understand much more about the reasons for its use than did those who were discussing the question fifty years ago; but there yet remains much to be learned.

It is not, however, the purpose of this paper to go into the historical part of the subject, or even to undertake a bibliographic review but rather to set forth some results which show the influence of lime as a factor in maintaining soil fertility.

Those who are at all fimiliar with the subject have often heard the expression, "Lime makes the father rich, and the son poor," the meaning of which, no doubt, briefly expressed, was that lime aids in "mining" the soil, rather than in building it up permanently.

We now know that the words quoted above do not necessarily express the facts. More recent investigations have led to the revision of the old adage, which is perhaps best summed up in Professor Vivian's four lines, as follows:

> Lime and lime without manure
> Make both farm and farmer poor;
> But lime, manure and vigorous clover
> Make the old farm rich all over.

It will be noted that the original phrase makes no reference to the use of organic matter in connection with lime. It is with the hope of giving a better understanding of the use of lime in agriculture, and especially of its relation to soil improvement that this work is reported.

In 1908, a field experiment was laid out, having as its object a study of the nitrogen problem in crop production. The plan contemplated a study of the sources of nitrogen, the proper amount of nitrogenous fertilizers to be applied and a study of the question of denitrification.

On account of the important bearing which lime has on the nitrogen problem, two series of twenty plots each were prepared, with identical treatment so far as nitrogenous and other fertilizers were concerned; and to all the plots of one series lime was applied, while all the plots of the other series remained unlimed.

The soil is a sassafras loam, inclining to a sandy loam, which originally contained 0.11 per cent of nitrogen and 1.2 per cent of total carbon. Lime-requirement determinations were not made at the time the experiment was started, but if we may judge from determinations made later on unlimed plots, it is safe to assume that the lime requirement in 1908 was about 1,600 to 2,000 pounds of lime (CaO) for two million pounds of the soil. This land had not been under cultivation for a number of years, and it is certain that no lime had been applied within recent years.

The plots were laid out 1-20 acre in size, being about twice as long as wide. The crop rotation, as originally planned, was, one year of corn, two years of oats, a year of wheat and one of timothy. This was later changed so that there was one year of oats and two of timothy. This is a rotation that was practised more or less some years ago, but would perhaps not be applicable to present conditions. Since the experiment provides for a study of nitro-

genous fertilizer materials, no leguminous crop can be introduced in the rotation, either as one of the main crops or as a green-manure crop. However, it may be noted here that, during the summer and fall of 1912, much volunteer clover appeared in the timothy and made considerable growth after the latter had been cut. This clover was later dug out, dried and weighed, and analyzed for nitrogen.

The yield of dry matter from the limed plots was almost double that from the unlimed plots. Likewise, samples from the limed plots showed a higher percentage of nitrogen than samples from the unlimed plots.

The lime treatment has consisted of finely ground limestone, or oyster shells, at the rate of one ton per acre just before planting the corn in 1908, and two tons per acre again preceding the corn in 1913 and 1918, the liming thus taking place at intervals of five years. A careful record has been kept of the amount of nitrogen applied in the form of manure and fertilizers, and likewise of the amount removed by the crops. Samples of soil were collected for analysis previous to applying the lime in 1913, and again in the fall of 1917.

TABLE 1

LIME REQUIREMENT, TOTAL CARBON AND TOTAL NITROGEN, 1913

Plot No.	Fertilizer Treatment	A's Unlimed				B's Limed			
		Lime (CaO) Requirement per 2,000,000 lbs. Soil	Total Carbon	Total Nitrogen	Ratio C/N	Lime (CaO) Requirement per 2,000,000 lbs. Soil	Total Carbon	Total Nitrogen	Ratio C/N
		lbs.	per cent	per cent		lbs.	per cent	per cent	
1A, 1B..	Nothing	1400	1.390	0.1059	13.13	1200	1.061	0.0862	12.30
2A, 2B..	16 lbs. muriate of potash	2100	1.441	.1098	13.12	1000	1.143	.0871	13.12
3A, 3B..	32 lbs. acid phosphate	2100	1.282	.1042	12.30	1000	1.066	.0821	12.98
4A, 4B..	*Minerals only	2100	1 362	.1180	11.54	1100	1.153	.0855	13.48
5A, 5B..	Minerals, 1600 lbs. cow manure	2100	1.375	.1002	13.72	1200	1.439	.1030	13.97
6A, 6B..	" 1600 lbs. horse manure	2200	1.392	.0929	14.90	1500	1.428	.1028	13.89
7A, 7B..	Nothing	1600	0.951	.0790	12.03	1000	1.165	.0879	13.25
8A, 8B..	Minerals, 8 lbs. $NaNO_3$	1400	1.105	.0880	12.50	1100	1.076	.0801	13.43
9A, 9B..	" 16 lbs. $NaNO_3$	2100	1.152	.0921	12.50	1000	1.078	.0753	14.32
10A, 10B..	" $Ca(NO_3)_2$ equiv. to 16 lbs. $NaNO_3$	2100	1.139	.0941	12.10	1200	1.120	.0805	13.91
11A, 11B..	" $(NH_4)_2SO_4$ equiv. to 16 lbs. $NaNO_3$	2100	1.140	.0977	11.66	1500	1.015	.0801	12.67
12A, 12B..	" $CaCN_2$ equiv. to 16 lbs. $NaNO_3$	1400	1.032	.0869	11.87	1000	1.158	.0861	13.45
13A, 13B..	" dried blood equiv. to 16 lbs. $NaNO_3$	2100	1.138	.0925	12.30	1100	1.051	.0807	13.02
14A, 14B..	" fish equiv. to 16 lbs. $NaNO_3$	2100	1.256	.1014	12.38	1100	1.076	.0779	13.82
15A, 15B..	" concentrated tankage equiv. to 16 lbs. $NaNO_3$	1800	1.213	.0884	13.72	1200	0.929	.0717	12.96
16A, 16B..	" 800 lbs. green alfalfa	2100	1.197	.0891	13.43	1100	1.176	.0897	13.11
17A, 17B..	" 800 lbs. green wheat or rye	1600	1.263	.0950	13.29	1100	1.250	.0953	13.12
18A, 18B..	" 1600 lbs. cow manure and 16 lbs. $NaNO_3$	1600	1.467	.1088	13.48	1200	1.410	.1014	13.91
19A, 19B..	" only	1400	1.289	.0980	13.15	1100	1.114	.0809	13.77
20A, 20B..	" 800 lbs. green wheat or rye, 16 lbs. $NaNO_3$	1400	1.227	.0959	12.79	1100	1.137	.0832	13.67
	Average	1840	1.240	.0969	12.80	1140	1.152	.0859	13.41

* Minerals = 32 lbs. acid phosphate and 16 lbs. muriate of potash.

TABLE 2

LIME REQUIREMENT, TOTAL CARBON AND TOTAL NITROGEN, 1917

Plot No.	Fertilizer Treatment	A's Unlimed			B's Limed		
		Lime (CaO) Requirement per 2,000,000 lbs. Soil	Total Carbon	Total Nitrogen	Lime (CaO) Requirement per 2,000,000 lbs. Soil	Total Carbon	Total Nitrogen
		lbs.	per cent	per cent	lbs.	per cent	per cent
1A, 1B..	Nothing	1200	1.33	0.1033	alkaline	0.896	0.0770
2A, 2B..	16 lbs. muriate of potash	1200	1.33	.1173	alkaline	0.960	.0790
3A, 3B..	32 lbs. acid phosphate	1200	1.24	.1139	200	0.864	.0751
4A, 4B..	*Minerals only	1200	1.26	.1088	400	1.040	.0779
5A, 5B..	Minerals, 1600 lbs. cow manure	1000	1.44	.1185	alkaline	1.420	.1143
6A, 6B..	" 1600 lbs. horse manure	1600	1.57	.1230	600	1.480	.1190
7A, 7B..	Nothing	800	0.93	.0785	alkaline	1.020	.0821
8A, 8B..	Minerals, 8 lbs. $NaNO_3$	1000	1.03	.0883	200	1.010	.0787
9A, 9B..	" 16 lbs. $NaNO_3$	1000	1.13	.0975	200	0.961	.0810
10A, 10B..	" $Ca(NO_3)_2$ equiv. to 16 lbs. $NaNO_3$	1000	1.10	.0903	alkaline	1.010	.0779
11A, 11B..	" $(NH_4)_2SO_4$ equiv. to 16 lbs. $NaNO_3$	1800	1.21	.0904	600	1.060	.0819
12A, 12B..	" $CaCN_2$ equiv. to 16 lbs. $NaNO_3$	600	1.02	.0844	200	1.070	.0896
13A, 13B..	" dried blood equiv. to 16 lbs. $NaNO_3$	1200	1.23	.1063	400	0.975	.0826
14A, 14B..	" fish equiv. to 16 lbs. $NaNO_3$	1200	1.22	.1058	400	0.931	.0889
15A, 15B..	" concentrated tankage equiv. to 16 lbs. $NaNO_3$	1000	1.18	.0919	alkaline	0.887	.0803
16A, 16B..	" 800 lbs. green alfalfa	1000	1.14	.1012	400	1.100	.0904
17A, 17B..	" 800 lbs. green wheat or rye	1000	1.08	.0980	alkaline	1.150	.0952
18A, 18B..	" 1600 lbs. cow manure and 16 lbs. $NaNO_3$	1200	1.36	.1171	alkaline	1.480	.1190
19A, 19B..	" only	1200	1.01	.0872	alkaline	0.951	.0784
20A, 20B..	" 800 lbs. green wheat or rye, 16 lbs. $NaNO_3$	1200	1.03	.0908	alkaline	1.120	.0903
	Average	1130	1.19	.1006	180	1.070	.0879

* Minerals = 32 lbs. acid phosphate and 16 lbs. muriate of potash.

The manure and fertilizer treatment which was given these plots, together with the analytical data secured at the end of the first 5-year period, are set forth in table 1; while table 2 gives similar data for the second 5-year period. From table 1 it will be noted that the average lime requirement (by the Veitch method) for all the A plots (unlimed) was 1840 pounds, and for all the B plots (limed) 1140 pounds. Thus it will be seen that the one ton of ground limestone applied in 1908 was not sufficient to keep the soil in a neutral or alkiline condition for the five years.

In discussing the results set forth in the tables, it will not be possible to consider each plot separately, but rather they must be dealt with by means of averages as a whole, or by averages of groups of plots. Taking the averages for the two 5-year periods separately, it is of especial interest to note that the percentage of carbon and nitrogen is greater on the unlimed than on the limed plots. These averages tabulated separately are as follows:

	A's Unlimed		B's Limed	
	Carbon per cent	Nitrogen per cent	Carbon per cent	Nitrogen per cent
First 5-year period	1.24	0.0969	1.15	0.0859
Second 5-year period	1.19	0.1005	1.07	0.0879

From these figures it is clear that during the ten years covering the two rotations, both the limed and the unlimed plots were losing nitrogen, for it will be remembered that originally this soil contained about .11 per cent of nitrogen.

But the most significant fact is the greater loss of both carbon and nitrogen from the limed than from the unlimed plots. Here appears to be confirmation, through 10 years of experimental work, of the view which has been widely expressed, namely, that the use of lime tends to "burn out" the organic matter of the soil.

But perhaps this lost nitrogen and carbon can be accounted for through larger crop yields on the limed plots during the ten years. The yields of dry matter and total nitrogen recovered in these crops for the period should answer this question.

The averages for the 20 plots for the 10 years are as follows:

	Dry Matter Per Acre		Nitrogen Per Acre	
	A's Unlimed	B's limed	A's Unlimed	B's Limed
	pounds	pounds	pounds	pounds
First 5-year period	3657	3669	40.7	40.8
Second 5-year period	2768	2926	28.3	31.1

From these figures it will be noted that the average yields per acre on the unlimed and limed plots for the first 5 years are practically the same, and that for the second 5 years the difference amounts to less than 200 pounds of dry matter, and less than 3 pounds of nitrogen per acre.

What, then, has been gained by the use of lime? Clearly, there has been no gain, but on the other hand, a distinct loss, for the crops have not been appreciably increased, and the limed soils now contain less nitrogen, by about 250 pounds for the plowed acre, than the unlimed soils. Must we conclude then, that the crops grown in this rotation are not benefitted by the use of lime even on soils that are moderately acid? Judged by the averages, as reported above, they were not benefitted. The land has been gradually losing nitrogen and carbon, which means organic matter, and most surely the lime is *hastening* the process. What has happened here is just what we should expect.

The presence of carbonate of lime in the soil favors the development of microorganisms, and especially those that nitrify organic matter, and thus nitrogen is lost through the drainage water as nitrates and also, no doubt, by escaping into the air as ammonia or as the element nitrogen.

On the other hand, the acid condition of the unlimed soil acted as a partial preservative of the organic mater, while, at the same time, enough nitrogen became available, with that which was applied, to produce practically the same crop that was produced on the limed plots. Through constant cropping, without the use of leguminous green-manure crops, the soil is gradually being depleted of its supply of organic matter, and therefore of its reserve supply of available nitrogen, and this process is going on more rapidly on the limed than on the unlimed plots.

That the organic matter of the soil must be oxidised, that is, burned up, or "burned out," with the formation of nitrates and other simpler compounds, is enevitable, and this is the only way that plant-food can be made out of such material, but it is just as inevitable that the supply must be maintained by the addition of manures or green-manure crops if crop yields are to be increased or even maintained, and the soil saved from wearing out, since on this type of soil crop residues are not sufficient to maintain the reserve supply of organic matter that is required for maximum production.

It is quite possible that with a heavier type of soil, such residues, with the aid of commercial fertilizers, might maintain crop yields and soil fertility for a long time, even under the stimulating effect produced by the application of lime at stated intervals.

The statement previously made, that crop residues on this soil are not sufficient to maintain the supply of organic mater, is well borne out by some average yields from the limed and unlimed sections which are reported in table 3.

Plots 4 and 9 on both sections receive annual applications of mineral fertilizer, but no nitrogen is applied, hence they become check plots. The average for these two plots is reported in the first line of the table. It will be noted that in the first 5-year period the yields of dry matter and nitrogen were essentially the same on the limed and unlimed sections, the yield of dry matter being less than 1½ tons per acre. For the second 5-year period the yields were slightly higher on the limed than on the unlimed plots, but were distinctly lower on both than during the first 5-year period, the dry matter being less than one ton per acre in each case. Furthermore, the nitrogen in the soil from the limed plots is 0.02 per cent, or 400 pounds for the plowed acre, less than for the unlimed plots.

Seven of the plots, Nos. 9 to 15, inclusive, on both limed and unlimed sections, receive in addition to the minerals, equivalent amounts of nitrogenous fertilizers, at the rate of 320 pounds of nitrate of soda per acre, and results secured from these plots—limed and unlimed—should be comparable. These comparisons are made in the second line of the table, and here it will be noted that the yields of dry matter and nitrogen are essentially the same on the limed and unlimed plots for the first 5-year period, but that there is a slight increase on the limed plots for the second 5-year period. It may be pointed out, however, that the yield of dry matter on the unlimed plots is 1,000 pounds and the limed plots 800 pounds, less for the second 5-year period than for the first; and furthermore, that the soil on the limed plots contains about 240 pounds less of nitrogen in the plowed acre than the unlimed soil. Here is proof positive that, on this soil, with a fertilizer treatment considerably above the average, the crop residues are not sufficient to maintain crop yields and soil fertility, and that the loss of nitrogen from the limed plots more than outweighs the slight increase in crop yields on these plots.

TABLE 3

AVERAGE YIELDS OF DRY MATTER AND NITROGEN ON LIMED AND UNLIMED PLOTS

Treatment	First 5-Year Period				Second 5-Year Period				Nitrogen in Soil	
	Dry Matter		Nitrogen		Dry Matter		Nitrogen			
	A Unlimed	B Limed	A Unlimed	B Limed	A Unlimed	B Limed	A Unlimed	B Limed	A Unlimed	B Limed
	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	lbs.	per cent	per cent
Average of Plots 4 and 19 Check	2718	2545	27.77	26.23	1641	1980	16.67	19.97	0.0980	0.0781
Average of Plots 9 to 15 Receive equivalent amounts of N	4002	4105	44.50	45.51	2978	3312	29.92	34.03	.0950	.0831
Average of Plots 5 and 6 Receive 16 tons of manure per acre	5118	4492	55.87	50.11	4384	3790	43.26	39.81	.1207	.1167
Plot 18. Receives 16 tons of manure and 320 lbs. nitrate of soda per acre	5872	6198	73.59	74.70	4628	4764	51.06	52.65	.1171	.1190
Average	4428	4335	50.43	49.14	3408	3461	**35.23**	**36.61**	**.1077**	**.0992**

Plots 5 and 6, on both the limed and unlimed sections, receive each year 16 tons per acre of manure,—5 receiving cow manure and 6 horse manure. The results from these plots are reported in line 3 of the table, and may be compared with the results from the check plots, and with results from the plots which receive the commercial nitrogenous fertilizers. Here it will be noted that the limed plots have yielded even less than the unlimed plots, this being true for the entire 10 years. From these figures, it would appear that on these plots soil acidity was not a limiting factor. Indeed, there is good reason to believe that the lime hastened the disappearance of readily available nitrogen compounds. The high percentage of nitrogen in the soil of these plots at the end of the 10 years might be taken as disproving this assertion; but on the other hand, with such heavy applications of manure every year, the slowly available residues could easily account for a high percentage of total nitrogen in the soil.

Plots 18 A, unlimed, and 18 B, limed, received annually 16 tons of manure and 320 pounds of nitrate of soda per acre; and from line 4 in the table, it will be noted that these gave the highest yield of any. There is, however, little difference between the yields from the limed and unlimed plots, and, as in the other cases, the yields are less for the second 5-year period than for the first.

The lower yield for the second 5-year period which has been noted all along cannot be attributed entirely to soil depletion, for, as just pointed out, the supply of organic matter and nitrogen in plots 5, 6 and 18 have been well maintained. It must be attributed, partly at least, to a residual corn crop which followed the oats in 1910, whereas such residual crop was not introduced in the second 5-year period.

The increased yields shown in plots 18 A and 18 B over the average yields for plots 5 and 6 may be fairly attributed to the 320 pounds of nitrate of soda applied to the former, and this would seem to bear out the suggestion that a deficiency of available nitrogen, rather than soil acidity, was the limiting factor on plots 5 and 6.

A point of especial interest in connection with results from plot 18, is the fact that the nitrogen supply of the soil has not only been maintained, but slightly increased, and the further fact that the limed plot contained slightly more nitrogen than the unlimed plot. This is not true of any of the other fertilized plots.

But beyond this, as already noted, plot 18 gave the largest yield, and thus the largest return of nitrogen—an average of about 75 pounds per acre for the first 5-year period, as against an average of 27 pounds for the check plots.

The results secured from plots 5, 6 and 18 present a good illustration of the value of organic matter in maintaining a nitrogen reserve in the soil and in keeping up the yields. The fact that the cost of such heavy applications of manure and manure with nitrate of soda would make them prohibitive for general farm crops does not alter the case. It simply leads us to search for a more economical method of supplying the organic matter.

It is entirely possible, indeed, that the amount of manure or nitrate, one or both, might have been somewhat reduced without materially lowering the yields or impoverishing the soil. This is indicated by the fact that the loss of nitrogen on these plots was much greater than the loss from plots 9 A to 15 A and 9 B to 15 B, as shown by the following figures covering the second 5-year period:

Average recovery of nitrogen, plots 9 A to 15 A..............27.70 per cent
Average recovery of nitrogen, plot 18 A......................15.95 per cent
Average recovery of nitrogen, plots 9 B to 15 B..............28.50 per cent
Average recovery of nitrogen, plot 18 B......................15.21 per cent

In the light of the evidence presented in the foregoing tables, it is not surprising that, during the last quarter of a century, many farms in the Eastern United States have been abandoned on account of unproductiveness, for in very many cases crops have been removed from these farms year after year, and in return the land has received but scant applications of manure—sometimes only a few tons once in three or five years—and very little or more often no commercial fertilizer. One might as well hope for an increased flow of milk from a starved cow, or an increase in egg production from a neglected hen, as to hope that lands receiving such treatment should be kept up to their original point of fertility and yield satisfactory crops.

The results of these experiments would seem to show, beyond a doubt, that for the lighter coastal plain soils, lime has very little place in rotations which entirely omit legumes.

In a later paper, the authors will discuss the same subject, considering rotations including leguminous crops.

Fruit Growing and Dairying; A Desirable Farming Combination

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California fruit growing has undoubtedly reached the highest degree of specialization of any state in the Union. By this is meant that not only are whole districts devoted almost exclusively to fruit growing, but a single fruit may be the dominating crop. While six or eight different fruits might do equally well, the custom has grown up of producing only one or two simply because the growers desire to specialize. Not only have certain sections specialized on a single fruit, but whole sections of the country are devoted to fruits alone. This extreme degree of one-line farming has been carried on in several places for 35 or 40 years and very successfully too, but there is now good evidence that the soils are getting in bad shape.

For the most part the valley orchard soils are from 8 to 15 feet deep, indeed often 20 feet deep, and while the fertility is by no means exhausted, there is a very noticeable decline in the humus supply and nitrogen content. Undoubtedly, the cultural methods that have been given to the orchards have been responsible for the present soil troubles. During all the years the orchards have been growing, tradition has decreed that they be given clean cultivation throughout the growing season. Trees begin to grow in February and the leaves are green until December or later. During the period between April and November there is rarely any rainfall. While perhaps three-fourths of the orchard area of the state is under irrigation, the remaining 25 per cent is handled by dry-farming methods. Without actual reference to statistics, it is safe to say that during the seven months from April 1 to November 1, there is at least 95 per cent sunshine. It is easy to see that soil that is constantly stirred under these conditions is bound to have its humus supply burned up rapidly. The humus supply seems to be destroyed even more rapidly where the land is under irrigation. Perhaps this is due to the fact that the soil must be stirred as soon as possible after each application of water and sometimes it is cultivated too wet. This helps to kill the surface soil.

Fruit growers are now desperately calling on the Experiment Station to tell them how to secure a fresh humus supply. Different methods are being tried, but plowing under green-manure crops is perhaps the most general practice. However, this has not been very satisfactory. In the past it was not thought possible to grow summer cover crops without irrigation, but recently it has been found that certain varieties of beans planted early in the season will make sufficient growth to shade the ground during the hottest part of the summer. When such crops can be harvested so as to permit the plowing under of the bean vines, not only is more humus added to the soil than is ever supplied by using the heaviest green-manure crops grown throughout the winter and plowed under in early spring, but the nodules on the roots furnish considerable quantities of nitrogen. Mulching the soil throughout the summer by covering with straw, low-grade alfalfa, stable manure, grass, weeds, or any kind of litter that can be procured is being tried and is a great theoretical success, since mulches furnish both shade and organic matter. However, the mulching system has certain drawbacks: first, that of cost, as it should be remembered that where such mulches are most needed, no grain or alfalfa is grown to supply them and neither is there any live stock to produce the manure. Furthermore, unless a mulch is very deep, the orchard may have to be irrigated at least once during the summer.

A plan has been devised for irrigating the trees by means of basins. In order not to disturb the mulches, these basins being close up under the trees and largely shaded by the branches, they do not necessarily have to be cultivated after watering. The mulching system for improving the soil is still in an experimental stage. Efforts are now being made to grow alfalfa in deciduous orchards. There are two plans followed. One plan is to grade the land into large checks, so that it may be flooded with water two or three times during the season. Alfalfa must be heavily irrigated, if it is expected to produce more than three crops during the season. The second plan is to grow the alfalfa in strips between the rows. These strips are ridged in such a way that they can be irrigated independently of the trees. The bare strips immediately along the rows are used for irrigation furrows and, of course, are kept cultivated. Alfalfa does not seem to injure old orchards, but for some reason young trees never seem to thrive in an alfalfa field.

Undoubtedly, young trees may be overwatered when growing in alfalfa by the heavy irrigations necessary for alfalfa, but if not given too often old trees do not seem to be hurt. Where the grower can be satisfed with two or three crops of hay from the orchard, and is willing to manage the land for the best interests of the trees, and where the alfalfa is not seeded until the trees are in heavy bearing, it may be said that this kind of intercropping so far has proven to be a great success and the practice is on the increase. This manner of handling orchard soils has undoubtedly improved the physical condition and greatly added to the fertility.

In one of the old fruit valleys of the state it is related that the first agriculture of the region was cattle grazing, under the old Spanish grants, dating back to the 30's or earlier. The next era was cereal farming, the growing of oats and wheat chiefly. Next came a period of sugar-beet growing, and this was followed by a few years when beans occupied nearly all the land. Following the era of bean culture came the growing of apples. Twenty-five years ago this became perhaps the best known apple-growing region in the United States. From this valley apples were shipped all over the world wherever fruits of this kind could go. This region was a pioneer one in the use of boxed apples. During the past eight or ten years, this once famous region has had more than its share of troubles, chiefly marketing difficulties. Soil troubles are also beginning to develop. However, apples can still be very successfully grown there. While improvements in marketing conditions may tend to revive the industry, there are those who prophesy that the apple business will continue to decline, and that there is no hope for the district as a fruit region unless a large percentage of the land is devoted to other lines of agriculture, particularly stock raising. The reason advanced for this is, that only by a diversified agriculture which includes stock growing can the fertility of the land be maintained. In support of the belief that the fruit industry in the region under discussion will continue to decline, it is cited that the past history shows that first one and then another line of agriculture was tried, and with the exception of the first, which cannot be classed as farming, none of them included stock raising.

Another fruit section of California which is largely devoted to prunes, pears, cherries, and peaches, and is now perhaps the

most consistently prosperous fruit region in the state, is beginning to experience soil troubles. This district has had a history very similar to that of the apple region described. This district, while growing several different kinds of fruits, indeed being planted almost solidly to fruits to the extent of 80,000 acres or more, has practically no animal production or grain-crop growing interests. It is therefore argued by some that this region will eventually decline, because of the inability of the farmers to supply enough organic matter to the soil to build up its physical condition and to restore and maintain its fertility. While the fertility is by no means exhausted, there is no question but that the surface soil in many instances is in a very bad physical condition. The trouble here as elsewhere is no doubt due to long years of clean cultivation. The orchards, even those past 30 or 35 years of age, are still yielding good incomes on a valuation of from $800 to $1000 an acre, but the orchardists are fully alive to the realization that soil conditions may eventually become so bad as to imperil their investments. They fully appreciate that the danger is great on account of the high valuation of the land, and active measures have been initiated for soil improvement.

In the opinion of the writer, the best solution of the soil troubles of fruit growers would be to engage in dairying in connection with fruit growing. Most dairy farmers in California expect to buy most of their concentrated feed-stuffs. Much of the necessary hay could be produced on the land by growing alfalfa between the rows of trees. Of course, if a grower attempted to procure six crops a year in the orchard as he would from an open alfalfa field, he would undoubtedly ruin his orchard, but experience has shown that he can safely take two or three crops of hay from the orchard without injury to his fruits. Young orchards, those from 1 to 4 years of age, could be used for growing grain and sweet sorghums, but such crops could not be grown in among bearing trees. Beans, as has been pointed out, can always be grown, even in old orchards, or at least up to the time they shade 75 per cent of the ground.

The manure produced from a one-man dairy should be sufficient to rapidly build up the soil of a one-man orchard. The chief difficulty in combining dairying and orcharding is that it is rare to find combined in a single individual the proper love for

handling both cattle and trees. A more logical plan to pursue would be for two men—one a dairyman and the other a fruit grower—to conduct a joint enterprise, each owning half of the capital stock. At the present time many dairymen experience great difficulty in keeping enough competent labor. Even though competent labor were available, the small dairyman often finds the overhead cost of keeping enough help for the rush hours of the day too great to make the venture profitable. The fruit grower, on the other hand, finds that his labor peak load comes only about twice a year, and so he cannot afford to keep his help the year round. It has been demonstrated that the combined dairy and fruit farm can afford to employ relatively more help than either one alone could profitably use. Under this cooperative plan as much of the help as necessary could assist with the milking and care of the stock twice a day and enploy the rest of their time in the orchard. While such help might have to be paid a little better than the prevailing wages, this would tend to secure a better quality of labor. This plan was tried and found to be a success a few years ago in the thin soils of the Ozarks in the Middle West.

Many fruit growers who are farming valuable land could afford to employ a man to carry on dairying for them as a side line. Even though such a venture only paid expenses it would still be worth while for the sake of keeping up the fertility of the orchard soils and insuring the permanence of the fruit industry. There are reasons for believing that the present California practive of growing fruits alone will eventually result in those regions falling into economic decay.

The Desirability of Field Work for the Soils Student

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It is the purpose of this paper to call attention to some results of the training in soils received in our agricultural colleges as illustrated by the county agent whose job it is to meet the soil management problems of the farmers in his county. What kind of soil training will best equip the student for this purpose?

The desire for more information on a particular subject, like soils, can be met only by spending an unusual amount of time on that subject as defined within somewhat narrow limits. We can teach no more than has been disclosed by investigation and verified experience. In our eagerness to attain more information we specialize increasingly, and by so doing new fields are revealed which compel us to continue the search and to limit specialties within narrower and narrower limits. But the limit time sets on the activity of an individual investigator forces him to seek help, and so he sets others to working out some of its details, or finds other investigators meeting him with the information he had hoped to discover. Such methods of work have been highly fruitful of definite results and denote progress with which the scientific world is constantly being surprised and gratified. Manifestly, successful investigation of this kind depends on closely limiting the boundaries of the field; and our investigational work is very properly organized in this way. It is clear, however, that the investigator thus engaged will not have time, if perchance he has the inclination, to work out the relationship of his own special subject to the college curriculum as a whole. Indeed, we do not expect him to do this.

In teaching soils we take the fund of information thus acquired and proceed to parcel it out within the same narrow lines. And this we believe to be sound in the elementary courses. Until the student is able to think clearly in terms of the special subject studied, the consideration of its relationships to other subjects would undoubtedly be disturbing and so interfere with securing a sound ground-work in the special subject itself.

But when the student has secured a fair measure of such groundwork, the more advanced courses, it is believed, should always bring out in a very direct and definite way the relationships of the special subject to other related subjects. Furthermore, before graduating a student the college should hold itself responsible for teaching him the definite connection between his educational course acquired in college and the business of profitable farming. The agricultural college will never satisfy the farmers of the nation until it does this; nor should it expect to do so.

The educational value of a college course is not lessened by applying to it the measuring stick of sound economics and by knowing that the adoption of its teaching will make the farm pay better. The principles of political economy and sound business management apply as well to the plan and arrangement of the college course itself as to the marts of trade and to business organization generally outside the college. A good course in farm management will start the soils student to thinking along this line. It will lead him to ask questions—usually for the professor to answer, though unfortunately the professor has rarely had sufficient chance to acquire much field experience himself. This has not been his fault. He has fitted himself into the teaching organization as it has developed and there has been little opportunity for him to carry on farm study. Many teachers feel keenly the lack of just this experience. If, however, the soils student is effectively to help develop the soil resources of the nation, through helping farmers to make their soil management more profitable, he must have at his finger tips not only a knowledge of the different phases of effective soil management, but he must be able to see each soil problem in its proper relation to the larger problem of farm management. Fortunately, extension work has now proceeded far enough to permit certain deductions, particularly through the experiences of the county agents, practically all of whom have been graduated from the agricultural colleges.

The best county agents eventually find that their real job is not to correct some detail that is hindering profiable farming, but rather to outline profitable farming itself and then be able incidentally to prescribe as occasion arises for every detail that may bear on such farm business. Applying this principle to soils, it means that the county agent cannot satisfy the farmers of his

county through years of service by recommending the soil treatments he has learned in college,—drainage, the application of lime, special fertilizers, various processes of tillage, or what-not. His job, the same as the farmer's, is to get maximum amounts of those crops profitably grown for cash and for feed to farm animals. And these crops must be those best adapted to local conditions, and soils. He must also secure the effective distribution of the labor of men and teams, providing employment as continuously as posible. Let us illustrate the situation:

The most difficult factor of soil fertility to be maintained is the organic content, not alone of plow depth but for the whole zone of soil which the crop roots reach, or may be made to penetrae. Such organic supply can be arranged for only through very definite field familiarity with the habits of growth of all farm crops suited to the region, whether or not they are now being grown. Consequently, the soils management man in extension work must also be a good crops man.

We believe the agricultural college has not fulfilled its function for the student majoring in soils unless he has reached at graduation the comprehensive point of view here outlined. This need not lengthen the college course; and we are not pleading for post graduate work, which at best only a few can undertake. It is believed the end can be accomplished by using approximately three-fourths of the summer vacations, and probably part of the spring term for field work on the farm. This work should not be hit-or-miss, nor should it be outlined in great detail. But an important farm business problem relating to soil management and based on a profitable cropping system should be assigned that would compel the application for at least the last two years of the college course, of some of the more important principles taught. While a thesis should be prepared covering each year's field work, additional conferences and discussions of problems should be depended upon to bring out the development of the student's thought; for, after all, learning how to think accurately on actual farm problems is the end sought.

Field service with the soil survey gives excellent training in learning different kinds of soils, how to distinguish soil differences that require different treatments in farm practice, together with types and degrees of crop development under a broad range of soil

and related climatic conditions. Those planning to teach soils and others who can arrange to do so will do well to get some experience in this work. Unfortunately, the opportunities to do this are somewhat limited, as the Bureau of Soils and the few states doing soil survey work do not make a general practice of training men unless they plan to continue the work long enough to render some efficient service in return. Whenever possible, however, summer work of this kind should be included.

For one planning to do graduate work in soils a full year on the Soil Survey before beginning graduate courses at the college is entirely feasible. It gives, in a short period of time, a point of view based on field and farm contacts that can hardly be secured in any other way.

In view of the opportunities that may be aranged it is unfair to the student, we believe, to grant him a degree in soils or crops that is not based in part on a very definite amount of field work.

Byron David Halsted

Byron David Halsted

June 7, 1852. August 28, 1918.

With the passing of Byron David Halsted we have lost one of our pioneer botanists. He was of that group of botanists who laid the foundation of the science in America at a time when the subject was recognized by very few American colleges and universities. He was one of a still smaller group who took up the study of applied botany and worked faithfully for its advancement.

Our younger plant pathologists know how difficult it is to find a disease of an economic crop that is not at least mentioned in his reports. He was among the first to report the introduction of several foreign pathogenic organisms.

Born at Venice, Cayuga County, New York, the son of David and Mary Halsted, he was left an orphan at an early age and was cared for by relatives. He graduated from the Michigan Agricultural College with the degree of Bachelor of Science in 1871, and received the degree of Master of Science from the same college in 1874. He then taught school for two years, and entered Harvard in 1875. In 1878 he received the degree of Doctor of Science from Harvard, being the first man to take the doctorate in cryptogamic botany from the university. He was managing editor of the "American Agriculturist" from 1879 to 1885; Professor of Botany in the Iowa Agricultural College, 1885-1889; and Professor of Botany in Rutgers College and Botanist of the New Jersey Agricultural Experiment Station from 1889 until his death. If he had lived until February, 1919, he would have rounded out a full 30 years in the service of the State of New Jersey. During the greater part of these 30 years he was active in both College and Station, but in the latter part of his career poor health necessitated his retirement from the classroom.

A widow and three children survive him: Edwin Howe Halsted, Sussex, N. J.; Mrs. Rudolph Riege, Springfield, Mass.; and Ella Halsted, New Brunswick, N. J.

Although a very busy man, he found time to serve his science by acting as Associate Editor of the Bulletin of the Torrey Botanical

Club from 1890 to 1893, and as a contributor to the Systematic Flora of North America. In 1877 the Massachusetts Horticultural Society honored him with its silver medal. He was a Fellow in the American Association for the Advancement of Science, and a member of the Society of Plant Morphology and Physiology, and served as president of the Society for the Promotion of Agricultural Science from 1877 to 1879, and of the Botanical Society of America in 1900-01.

Dr. Halsted was a true lover of nature, and nature made him a most warm-hearted and lovable man. He was a most enthusiastic collector, furnishing material not only for his own studies, but also a great quantity for study by other mycologists and from which many new species were described. In fact, many of the mycological collections of America and in other countries as well, contain material contributed by him. He was among the first to report the introduction of several foreign diseases into America.

While generally regarded as a scientist of the old school, still he was an up-to-date botanist in every way. After devoting the greater part of his career to mycology, poor health and failing eyesight forced him to abandon his favorite line of work. He could not leave the field of botany, however, but merely transferred his efforts to plant breeding, which did not require the use of the microscope, and worked with the renewed energy and the enthusiasm of a boy.

Dr. Halsted was more than a botanist; he was a broad, scholarly man and a public spirited citizen. He was always interested in athletics and in his youth was an amateur baseball pitcher. He never lost his interest in the sport, but was a regular attendant at intercollegiate games, always placing himself so that he could observe the work of the pitcher. His love for literature and his keen interest in the state and comumnity were manifested by a poem which he wrote on the occasion of a civic parade when the nation was called to arms in 1917.

To the literature on Botany and Plant Pathology, Dr. Halsted contributed over 300 titles. Also, he was the author of "The Vegetable Garden" (1888), "Farm Conveniences" (1888), and "A Century of Agricultural Weeds" (1891).

The following words of his nephew, Dr. David G. Fairchild, accurately characterize the man:

"With Dr. Halsted's death, there has passed not only a great soul, whose ideals live in his pupils, but a personality in research which was characteristic of an epoch in botanical science—the early days of plant pathology.

"To those who, in their researches, run across one of his new species of fungi or early descriptions of plant disease, I would point out, that behind the descriptions which they read, lies the soul and intellect of an American who believed that the evolutionary drift of mankind is toward a greater altruism."

(Adapted from an article by Dr. M. T. Cook in the "Botanical Gazette," February, 1919).

Thomas Shaw*

Thomas Shaw was born at Niagara-on-the-Lake, Ontario, January 3, 1843, and died June 24, 1918. In his early years he was a teacher in the district schools, and in 1888 he became Professor of Agriculture at the Ontario Agricultural College. Five years later he went to the Minnesota College of Agriculture as Professor of Animal Husbandry, where he remained ten years. From 1903 to 1908 he was Editor of the *Farmer,* published at St. Paul, Minn., and since was Northwest Editor of Orange Judd publications, with his home at St. Paul.

Professor Shaw was made President of the Board of Trustees of Macalester College in 1899. He was active as a Farmers' Institute lecturer, and his investigations and writings were in the field of animal breeding and feeding, forage and soiling crops, grasses and clovers, weeds, sheep husbandry, and the growing of cereals.

Professor Shaw's son, Robert Sidney Shaw, is Dean of the Agricultural College and Director of the Agricultural Experiment Station of Michigan.

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* Compiled from "American Men of Science," 1910.

MEMBERSHIP OF THE SOCIETY

Honorary Member

1899—HON. JAMES WILSON, LL.D., *Traer, Iowa.*

Regular Members

(Arranged Alphabetically.)

The prefixed date is the year of election.

1907—EDWIN WEST ALLEN, B.S. (Mass. Agri. Coll. and Boston Univ., '85), Ph.D. (Gottingen, '90); *U. S. Dept. Agri., Washington, D. C.;* Asst. Chem. Mass. Expt. Sta., '85-'88; Asst. Office Expt. Stas., '90-'93; Asst. Dir., do., '93—; Ed. Expt. Sta. Record, '95—.

1913—HARRY ORSON ALLISON, B.S. (Univ. Ill., '06), M.S. (do., '06); *Columbia, Mo.;* Instr. and Asst. Anim. Husb., Univ. Ill., and Expt. Sta., '06-'10; Asst. Prof. Anim. Husb., Univ. Mo., '10-'12; Assoc. Prof. do., and Anim. Husb. Mo. Expt. Sta., '12—.

1913—JOHN W. AMES, B.S. (Case School Appl. Sci., '98), M.S. (do., '06); *Wooster, Ohio;* Chem., Ohio Expt. Sta., '99—.

1889—HENRY PRENTISS ARMSBY, B.S. (Worcester Poly. Inst., '71), Ph.B (Sheffield Sci. School, '74), Ph.D. (Yale Univ., '79), LL.D. (Univ. Wis., '04); *State College, Pa.;* Chem. Conn. Expt. Sta., '77-'81; Vice Prin. Storrs Agr. School, '81-'83; Prof. Agr. Chem., Univ. Wis., '83-'87; Dir. Pa. Expt. Sta., '87-'07; Dean School of Agri., Penn. State College, '95-'02; Dir. Inst. Animal Nutrition, '07—.

1886—JOSEPH CHARLES ARTHUR, B.S. (Iowa State Coll., '72), M.S. (do., '77), D.Sc. (Cornell Univ., '86); *Lafayette, Ind.;* Inst. Biol., Iowa State Coll., '76-'78; Instr. Bot., Univ. Wis., '79-'81; do., Univ. Minn., '82; Bot. N. Y. Expt. Sta., '84-'87; Prof. Bot., Purdue Univ., '87-'88; Prof. Veg. Phys. and Path., do., and Bot., Ind. Expt. Sta., '88-'15; Prof. Emeritus Bot., Purdue Univ., '15—.

1906—LIBERTY HYDE BAILEY, B.S. (Mich. Agr. Coll., '82), M.S. (do., '85), LL.D. (Univ. Wis., '07); *Ithaca, N. Y.;* Prof. Hort. and Landscape Gardening, Mich. Agr. Coll., '84-'88; Prof. Hort., Cornell Univ., '88-'03; Dir. Coll. Agr. and Expt. Sta., Cornell Univ., '03-13; Editor and Writer, '13—.

1914—ELMER DARWIN BALL, B.S. (Iowa St. Coll., '95); M.S. (do., '98), Ph.D. (Ohio State Univ., '07); *Madison, Wis.;* Asst. in Zool. and Ent., Iowa St. Coll., '95-'97; Asst. in Zool. and Ento., Colo. Agr. Coll., '97-'02; Prof. Zool. and Ento., Utah Agr. Coll., '02-'07; Dean School Agr. and Dir. Expt. Sta., Utah Agr. Coll., '07-'17; State Ent., Wis., '17—.

1879—William James Beal, A.B. (Univ. Mich., '59); A.M. (do., '63), Sc.B. (Harvard Univ., '65), Sc.M. (Univ. Chicago, '75), Ph.D. (Univ. Mich., '80), D.Sc. (Mich. Agr. Coll., '05); *Amherst, Mass.;* Prof. Bot. Mich. Agr. Coll., '70-'72; Prof. Bot. and Hort., '72-'81; Prof. Bot. and Forestry, '81-'03; Prof. Bot., '03-'10; Prof. Emeritus, '10—.

1916—Orville Andrew Beath, B.A. (Univ. Wis., '08); M.S. (do., '12), Instr. H. S. Science; Instr. Chem., Univ. of Kansas, '12-'14; Asst. Chem., U. S. Forest Products Lab., '14; Research Chem., Univ. Wyo., '14—.

1912—Augustine Wilberforce Blair, B.S. (Haverford, '92), A.M. (do., '96); *New Brunswick, N. J.;* Prof. Chem., Guilford Coll., '96-'97; Asst. Chem., N. C. Expt. Sta., '97-'98; State Chem., N. C., '98-'99; Asst. Chem., Fla. Expt. Sta. and Univ., Fla., '99-'06; Chem. Fla. Expt. Sta., '06-'12; Assoc. Soil Chem., N. J. Expt. Sta., '12—.

1913—Maurice Adin Blake, B.S. (Mass. Agr. Coll., '04); *New Brunswick, N. J.;* Asst. Hort., R. I. Agr. Coll. and Expt. Sta., '04-'05; Instr. Hort., Mass. Agr. Coll., '05-'06; Hort., N. J. Expt. Sta. and Prof. Hort., Rutgers Coll., '06—; Acting State Leader of Farm Demonstration, '18—.

1893—Henry Luke Bolley, B.S. (Purdue Univ., '88), M.S. (do., '89); *Agricultural College, N. Dak.;* Instr. Biol. and Asst. Bot. to Expt. Sta., Purdue Univ., '90; Prof. Bot. and Plant Path., N. Dak. Agr. Coll. and Bot. and Plant Path. of Expt. Sta., do., '90—.

1909—William Penn Brooks, B.Sc. (Mass. Agr. Coll., '75), Ph.D. (Halle, '97); *Amherst, Mass.;* Prof. Agr. Imp. Coll. Agr., Sappora, Japan, '77-'88; Prof. Bot., do., '81-'88; Pres., do., *ad interim* '80-'83 and '86-'87; Prof. Agr. and Agn., Mass. Agr. Coll. and Expt. Sta., '89-'09; acting Pres. and Dir., do., '05-'06; Dir. Expt. Sta., '06-'19; Expert Consulting Agriculturist, '19—.

1901—Edgar Allen Burnett, B.S. (Mich. Agr. Coll., '87); D.Sc. (do., '17); *Lincoln, Nebr.;* Asst. Mich. Agr. Coll., '89-'93; Prof. Anim. Husb., S. Dak. Agr. Coll., '96-'99; Prof. Anim. Husb., Univ. Nebr., '99-'07; Dir. Nebr. Expt. Sta., '01—; Dean Coll. Agr., '09—.

1908—Kenyon L. Butterfield, B.S., (Mich. Agr. Coll., '91), A.M. (Univ. Mich., '02); *Amherst, Mass.;* Supt. Mich. Farmers' Institutes, '95-'99; Instr. Univ Mich., '02; Pres. Rhode Island Coll., '03-'06; Pres. Mass. Agr. Coll. and Head Div. Rural Sociol., '06—.

1909—Frank Kenneth Cameron, A.B. (Johns Hopkins, '91), Ph.D. (do., '94); *Washington, D. C.;* Fellow Cornell, '94-'95; Assoc. Prof., Catholic Univ., '95-'97; Asst. Physical Chem., Cornell, '97-'98; Expert, U. S. D. A., '98-'99; Soil Chemist, do., '99—.

1914—Ira Detrick Cardiff, B.S. (Knox Coll., '99); Grad. Stud. Univ. of Chicago, '02-'04; Ph.D. (Columbia Univ., '06); *Yakima, Wash.,* Asst. in Bot., Columbia Univ., '04-'06; Asst. Prof. of Bot., Univ. of Utah, '06-'07; Prof. of Bot., do., '07-'08; do. Washburn Coll.,

'08-'12; do. Univ. of Kans., '12; Prof. of Plant Physiol. and Bact., State Col. of Wash., '13; Dir., State Expt. Sta., State Coll. of Wash., '13-'17; Manag. Ira D. Cardiff & Co., '17—.

1908—Mark Alfred Carleton, B.S. (Kans. Agr. Coll., '87), M.S. (do., '93); *Washington, D. C.;* Asst. Bot., Kans. Expt. Sta., '92-'93; Cerealist, Bur. Plant Indus., U. S. D. A., '94-'12; Gen. Mgr., Penn. Chestnut Tree Blight Com., '12-'13; Cerealist, Bur. Plant Indus., U. S. D. A., '13—.

1915—William L. Carlyle, B.S. (Ontario Agr. Coll., '92), M.S. (Colo. Coll. '05); *Stillwater, Okla.,* in chg. Dairy School, Ontario, '93; Lect. Dairy and Live Stock, Minn. Farm Insts., '93-'97; Prof. Anim. Husb., Univ. of Wis., '97-'03; Prof. of Agr., Col. Coll. and Dean Coll. of Agr., '04-'08; Genl. Secy. A. J. Knollin Co., Denver, Colo., '08-'10; Dir. Idaho Expt. Sta., '10-'14; Dir. Okla. Expt. Sta., '14—.

1905—Louis George Carpenter, B.S. (Mich. Agr. Coll., '79), M.S. (do., '84), Asst. Prof., Mich. Agr. Coll., '85-88; Irr. Eng., Col. Agr. Coll. and Expt. Sta., '88-'10; Dir. Expt. Sta., do., '99-'10; State Eng., '03-'05; Consulting Irrigation Engineer, Denver, Colo., '10—.

1901—Louis Adelbert Clinton, B.S. (Mich. Agr. Coll., '89), M.S. (do., '97); *New Brunswick, N. J.;* Asst. to Dir. Mich. Expt. Sta., '89-'93; Asst. Prof. Agr., Clemson Coll., '93-'95; Asst. Agr., Cornell Expt. Sta., '95-'02; Dir. Storrs Expt. Stat. and Prof. Agr., Conn. Agr. Coll., '02-'12; Agriculturist, Bur. Plant Indus., '12-'15; Asst. Chief, Office of Extension Work, North and West, U. S. D. A., '15-'18; Director of Extension, N. J. State Coll., '18—.

1919—Robert Waitman Clothier, B.S. (Kans. Agr. Coll., '97), M.S. (do., '99), Ph.D. (Geo. Wash. Univ., '17); Asst. in Chem. Kans. Agr. Coll. and Expt. Sta., '97-'01; Prof. Chem. and Agr., Mo. State Norm. Sch., Cape Giradeau, '01-'06; Head Dept. Agr. Uuiv. Fla., '06-'07; Prof. Agr. and Acting Dean, Agr. Coll., Univ. Ariz., '07-'14; Agriculturist, Off. Farm Mgt., U. S. D. A., '14—.

1910—John Waldo Connaway, D.V.S. (Chicago Vet. Coll., '90), M.D. (Univ. Mo., '91); *Columbia, Mo.;* Prof. Physiology, Univ. Mo., '91-'97; Vet. Expt. Sta., do., '97-'00; Prof. Compar. Med. and Vet. to Expt. Sta., Univ. Mo., '00—.

1915—Thomas Cooper, B.S. of A. (Minn. Coll. of Agri., '08); *Lexington, Ky.;* Spec. Agt. Bureau of Statistics, '04-'10; Statistical Agt. and Asst., Minn. Expt. Sta., '04-'08; Asst. Agriculturist, Univ. of Minn., '08-'10; Asst. Agriculturist in Chg. Farm Mgmt., '10-'11; Dir. Better Farming Assn. of N. Dak., '11-'14; Dir. Agrl. Expt. Sta. and Dir. Agrl. Ext., N. Dak. Agrl. Coll., '14-'17; Dean Coll. Agr. and Dir. Expt. Sta., Univ. Ky., '17—.

1910—Lee Cleveland Corbett, B.S. (Cornell Univ., '90), M.S. (do., '96); *Washington, D. C.;* Asst. Hort., Cornell Univ., '91-'93; Prof. Hort. and Forestry, S. Dak. Coll., '93-'95; do., Univ. W. Va. and Expt. Sta., '95-'01; Hort., U. S. Dept. Agr., '01-'13; Asst. Chief Bur. Plant Indus., do., '13-'14; Hort., do., '14—.

1914—Arthur Burton Cordley, B.S. (Mich. Agr. Coll., '88), M.S. (do., '01); *Corvallis, Ore.;* Grad. Student, Cornell Univ., '00-'07; Asst. in Ento., Mich. Agr. Coll., '88-'90; Asst. Ento. Vt. Expt. Sta., '90-'91; Asst. Ento., U. S. D. A., '91-'93; Prof. Zool. and Ento. Expt. Sta., Ore. Agr. Coll., '95-'12; Dean, School for Agr., do., '07—; Dir. of Expt. Sta., do., '14—.

1902—Charles Francis Curtiss, B.S.A. (Iowa State Coll., '87), M.S.A. (do., '93), D.Sc. (Mich. Agr. Coll., '07; *Ames, Iowa;* Asst. Dir. Iowa Expt. Sta., '91-'97; Prof. Agr. and Acting Dir., Iowa Expt. Sta., '97-'00; Prof. Agr. and Dir., do., '00-'02; Dean and Dir., '02—.

1911—William Haddock Dalrymple, M.R.C.V.S. England, '86; *Baton Rouge, La.;* Prof. Vet. Sci., La. State Univ., '89—; Vet., La. Expt. Sta., '89—.

1906—Eugene Davenport, B.S. (Mich. Agr. Coll., '78); M.S. (do., '81), M. Agr. (do., '95), LL.D. (do., '07); *Urbana, Ill.;* Prof. Agr., Mich. Agr. Coll., '89-'90; Dir. Coll. of Agr., Piracicaba, Brazil, '91-'92; Dean Coll. of Agr., Univ., Ill., '95—; Dir. Agr. Expt. Sta., '96—; Dir. Agr. Ext., '14—.

1913—Robert John H. DeLoach, A.B. (Univ. Ga., '98), A.M. (do., '06); *Experiment, Ga.;* Bot., Ga. Expt. Sta., '06-'08; Prof. Cotton Indus., Univ. Ga., '08-'13; Dir., Ga. Expt. Sta., '13—.

1911—William Rufus Dodson, B.S. (Univ. Mo., '90), A.B. (Harvard Univ., '94); *Baton Rouge, La.;* Asst. Biol., Univ. Mo., '90-'93; Prof. Bot., La. Univ., '94-'02; Asst. Dir. La. Expt. Stas., '02-'05; Dir., do., '05—; Dean, Coll. Agr., La. Univ., '09—.

1910—John Frederick Duggar, B.S. (Miss. Agr. Coll., '87), M.S. (do., '88); *Auburn, Ala.*; Asst. in Agr., Tex. Agr. Coll., '87-'89; Asst. Dir., S. C. Expt. Sta., '90-'92; Agr. Editor Office Expt. Stas., U. S. D. A., '93-'95; Prof. Agr., Ala. Poly. Inst., '96—; Dir. Ala. Expt. Sta., '03—.

1913—Clarence Henry Eckles, B.S.A. (Iowa State Coll., '95), M.S. (do., '97); *St. Paul, Minn.;* Instr. and Asst. in Dairying, Iowa Coll. and Expt. Sta., '96-'01; Asst. Prof. Dairy Husb. Univ. Mo., and Dairyman, Mo. Expt. Sta., '01-'06; Prof. and Dairyman, do., '06-'18; Chief Dairy Husb. Div., Univ. Minn., 1918—.

1899—David Grandison Fairchild, B.S. (Kans. State Coll., '88), M.S. (do., '93); *Washington, D. C.;* Naples Zool. Sta., '93; Breslau and Berlin, '94; Bonn, '95; Buitenzorg Botanic Gardens, '96; Asst. Path. U. S. Dept. Agr., '89-'92; Special Agt. in Charge Seed and Plant Production, '97-'98; Agr. Explorer, '98-'03; in charge Foreign Seed and Plant Production, U. S. Dept. Agr., '03—.

1880—William Gibson Farlow, A.B. (Harvard Univ., '66), M.D. (do., '70), LL.D. (do., '96; Univ. Glasgow, '01; Univ. Wis., '04); 24 *Quincy St., Cambridge, Mass.;* Asst. Prof. Bot., Harvard Univ., '74-'79; Prof. Cryptg. Bot., do., '79—.

1890—Bernhard Edward Fernow (Munden Forest Acad. Grad., '73), LL.D. (Univ. Wis., '97; Queen's, '03); *Toronto, Can.;* Chief, Div.

Forestry, U. S. Dept. Agr., '86-'98; Dir. N. Y. State Coll. of Forestry, '98-'03; Lecturer Yale Forestry School, '04; Prof. of Forestry, Univ. of Toronto, '07—.

1911—MARTIN LUTHER FISHER, B.S. (Purdue Univ., '03), M.S. (Univ. Wis., '11); *Lafayette, Ind.;* Asst. in Agr., Purdue Univ., '03-'04; Inst. Agr., do., '04-'06; Asst. Prof. Agron., do., '06-'08; Assoc. Prof. Agron., do., '08-'10; Prof. Crop Prod., do., '10—; Asst. Agr., Indiana Expt. Sta., '03-'10; Assoc. in Crops, do., '10—.

1910—ERNEST BROWNING FORBES, B.Sc. (Univ. Ill., '97), B.S.Agr. (do., '02), Ph.D. (Univ. Mo., '08); *Wooster, Ohio;* Zool. Asst., Ill. Biol. Sta., '94-'96; Asst. to State Ento. of Minn., '97-'98; Acting State Ento. Minn., '01; Asst. in Anim. Husb., Ill. Expt. Sta., '01-'02; Instr. Anim. Husb., Univ. Ill., '02-'03; Asst. Prof. Anim. Husb., Univ. Mo., '03-'07; Chief in Nutr., Ohio Expt. Sta., '07—.

1908—STEPHEN ALFRED FORBES, Ph.D. (Ind. Univ., '84), LL.D. (Univ. Ill., '05), *Urbana, Ill.;* Prof. Zool., Univ. Ill., '84-'09; State Ento. Ill., '82—; Dir. Ill. State Lab. of Nat. Hist., '77—; Dean Coll. of Sci., Univ. of Ill., '88—.

1916—JULIUS HERMAN FRANDSEN, B.S.A. (Iowa State Agr. Coll, '02), M.S. (do., '04), Asst. Chem. Iowa Expt. Sta., '04-'06; Com'l Dairy Work, Portland, Ore., '06-'09; Prof. Dairy Husb., Moscow, Ida., '09-'11; Prof. Dairy Husb., Univ. of Nebr., Lincoln, Nebr., '11—.

1911—GEORGE STRONACH FRAPS, B.S. (N. C. Agr. Coll., '96), Ph.D. (Johns Hopkins Univ., '99); *College Station, Tex.;* Asst. Prof. Chem., N. C. Agr. Coll., and Asst. Chem. in Expt. Sta., '99-'03; Asst. Chem., Tex. Expt. Sta., '03-'04; Assoc. Chem., do., '04-'05; Chem., do., '05—; Assoc. Prof. Chem., Tex. Agr. Coll., '03-'05; Acting Prof., do., '05-'06; Assoc. Prof. Agr. Chem., do., '06—; State Chem., '06;

1888—WILLIAM FREAR, A.B. (Bucknell Univ., '81), Ph.D. (Ill. Wesleyan Univ., '83); *State College, Pa.*; Asst. Sci., Bucknell Univ., '81'-83; Asst. Chem., U. S. Dept. Agr., '83-'85; Prof. Agr. Chem., Pa. State Coll., '85—; Vice Dir. and Chem., Pa. Expt. Sta., '87—.

1913—JONS AUGUST FRIES, B.S. (Pa. State Coll., '99), M.S. (do., '06); *State College, Pa.;* Asst. Chem., Pa. Expt. Sta., '89-'98; Expert Asst. Anim. Nutr., do., '98-'08; Asst. Dir. Inst. Anim. Nutr., '08—.

1908—BEVERLY THOMAS GALLOWAY, B.S. (Univ. Mo., '84), LL.D. (do., '02); *Washington, D. C.;* Asst. Hort., Univ. Mo., '84-'87; Asst. Path., U. S. Dept. Agr., '87-'88; Path. and Chief, Div. Veg. Path. and Physiol., do., '88-'01; Chief Bur. Plant Indus., do., '01-'13; Asst. Sec. of Agr., '13-'14; Dean N. Y. State Coll. of Agr. at Cornell Univ.; Dir. Cornell Univ. Agr. Expt. Sta. and Agr. Ext., '14-'16; Plant Path., Bur. Plant Indus., U. S. Dept. Agr., '16—.

1894—HARRISON GARMAN, D.Sc. (St. Univ. of Kentucky); *Lexington, Ky.;* First Asst. State Lab. Nat. History., Ill., '83-'89; Asst. Prof. Zool., Univ. Ill., '85-'89; Ento. and Bot., Ky. Expt. Sta., '89—; State Ento., Ky., '97—; Prof. of Ento. and Zool., St. Univ. of Kentucky, '11—.

1894—Charles Christian Georgeson, B.S. (Mich. Agr. Coll., '78), M.S. (do., '82); *Sitka, Alaska.;* Asst. Ed. of *Rural New Yorker*, '78-'80; Prof. Agr. and Hort., Tex. Agr. Coll., '80-'83; Prof. Agr. Coll. of Agr., Imperial Univ., Tokyo, Japan, '86-'89; Prof. Agr., Kans. State Agr. Coll., '90-'97; Special Agt. U. S. Dept. Agr., Dairy Industry, Denmark, '93; Asst. Agrostologist, U. S. Dept. Agr., '97-'98; Special Agt. in charge Alaska Expt. Sta., do., '98—.

1893—Clarence Preston Gillette, B.S. (Mich. Agr. Coll., '84), M.S. (do., '88); D.Sc. (do., '17); *Fort Collins, Colo.;* Asst. Zool., Mich. Agr. Coll., '87-'88; Ento. Iowa Expt. Sta., '88-'91; Prof. Zool. and Ento., Colo. Agr. Coll. and Ento. Expt. Sta., do., '91—; Dir. Expt. Sta., do., '10—; Colo. State Ento., '07—.

1911—Arthur Goss, B.S. (Purdue Univ., '88), M.S. (do., '95); *Lafayette, Ind.;* Asst. Chem., Ind. Expt. Sta., '88-'92; Asst., Ind. Weather Serv., '89-'92; Prof. Chem., N. Mex. Agr. Coll. and Chem. in Expt. Sta., '92-'03; Vice-Dir., N. Mex. Expt. Sta., '95-'00; Dir. Ind. Expt. Sta., '03—.

1916—Howard John Gramlich, B.S. (Univ. of Nebr., '11); Vice-Dir. Extension Work Nebr., '11-'13; Prof. Anim. Husb., do., '13—.

1909—Harry Sands Grindley, B.S. (Univ. Ill., '88), Sc.D. (Harvard, '94); *Urbana, Ill.;* Asst. Chem., Univ. Ill., '88-'92; Asst. Chem., Harvard, '92-'93; Fellow Harvard, '93-'94; Instr. Chem., Univ. Ill., '94-'95; Asst. Prof. Chem., do., '95-'99; Assoc., Prof. Chem., do., '99-'04; Prof. and Dir. Chem. Lab., do., '04-'07; Prof. An. Chem., do., and Chief An. Chem., Expt. Sta., '07—.

1909—Theophilus L. Haecker, *University Farm, St. Paul, Minn.;* in charge Dairy Husb., Minn. Univ. and Expt. Sta., '92-'07; Prof. Dairy Husb. and Anim. Nutrition, do., '07-'09; Prof. Dairying, Anim. Husb. and Animal Nutrition, do., '10—.

1902—Niels Ebbensen Hansen, B.S. (Iowa State Coll., '87), M.S. (do., '95); *Brookings, S. Dak.;* Asst. Prof. Hort., Iowa State Coll., '91-'95; Prof. Hort. and Forestry, S. Dak., Agr. Coll., and Hort., Expt. Sta., '95—.

1910—Joseph Nelson Harper, B.S. (Miss. Agr. Coll., '95), M.A. (Ky. Agr. Coll., '06); *Clemson College, S. C.;* Dairy Husb., Miss. Expt. Sta., '95; Dairy Husb., Ky. Expt. Sta., '96-'98; Agriculturist, do., '98-'05; Dir. and Agron., S. C. Expt. Sta., '06—.

1910—Burt Laws Hartwell, B.S. (Mass. Agr. Coll. and Boston Univ. '89), M.S. (Mass. Agr. Coll., '00), Ph.D. (Univ. Pa., '03); *Kingston, R. I.;* Asst. Chem. Mass. Expt. Sta., '89-'91; Asst. Chem., R. I. Expt. Sta., '91-'03; Assoc. Chem., do., '03-'07; Chem., do., '07—; Prof. Agr. Chem., R. I. State Coll., '08—; Dir., R. I. Expt. Sta., '12—; Agron., R. I. Expt. Sta., '13—.

1905—Willet Martin Hays, B.Agr. (Iowa State Coll., '85), M.Agr. (do., '86); *Kennett Sq., Pa.;* Asst. Iowa State Coll., '86; Assoc. Ed., *Prairie Farmer*, '87; Asst. in Agr., Iowa Agr. Coll., '88-'89; Prof. Agr. and Agrlst., Minn. Agr. Coll. and Expt. Sta., '90-'91; do., N. Dak. Agr.

Coll. and Expt. Sta., '92-'93; do., Minn. Agr. Coll. and Expt. Sta., '93-'04; Asst. Sec. of Agr., U. S. Dept. Agr., '04-'13; Farmer, '15—.

1911—HARRY HAYWARD, B.S. (Cornell Univ., '94), M.S. (do., '01); *Newark, Del.,* Asst. Prof. Dairy Husb., Pa. State Coll., '97-'02; Assoc. Prof. Anim. and Dairy Husb., N. H. Agr. Coll., '02-'03; Asst. Chief Dairy Div., U. S. Dept. Agr., '03; Dir. Agr. Dept., Mount Hermon School, '03-'06; Dean Agr. Dept., Del. Coll., and Dir. Del. Expt. Sta., '06—; Dir. Agrl. Ext., '14—.

1909—WILLIAM PARKER HEADDEN, A.B. (Dickinson, '72), A.M. (do., '75), Ph. D. (Univ. Giessen, '74); *Fort Collins, Colo.;* Asst., Univ. Pa., '74-'76; Prof. Chem., Md. Agr. Coll., '80-'84; do., Univ. Denver, '84-'89; do., S. Dak. School of Mines, '89-'91; Dean, do., '92-'93; Prof. Chem. and Geol., Colo. Agr. Coll., and Chem., Expt. Sta., '93—.

1909—ULYSSES PRENTISS HEDRICK, B.S. (Mich. Agr. Coll., '93), M.S. (do., '95); *Geneva, N. Y.;* Asst. Hort., Mich. Agr. Coll., '93-'95; Prof. Bot. and Hort., Ore. Agr. Coll., and Hort., Expt. Sta., '95-'97; Prof. Bot. and Hort., and Hort., Expt. Sta., Utah, '97-'99; Prof. Hort., Mich. Agr. Coll., '99-'05; Hort., N. Y. Expt. Sta., '05—.

1905—JOSEPH LAWRENCE HILLS, B.S. (Mass. Agr. Coll. and Boston Univ., '81), D.Sc. (honorary, '03, Rutgers Coll.); *Burlington, Vt.;* Asst. Chem., Mass. Expt. Sta., '82-'83; Asst. Chem., N. J. Expt. Sta., '84-'85; Chem. Phos. Mining Co., Ltd., Beaufort, S. C., '85-'88; Chem., Vt. Expt. Sta., '88-'98; Dir., do., '98—; Prof. Agr. Chem. Univ. Vt., '93—; Dean, Dept. Agr., do., '98—.

1889—LELAND OSSIAN HOWARD, B.S. (Cornell Univ., '77), M.S. (do., '86), Ph.D. (Georgetown Univ., '96); *Washington, D. C.;* Asst. Ento., U. S. Dept. Agr., '78-94; Chief Ento., do., '94—; Perm. Sec., A. A. A. S., '98—.

1912—WALTER LAFAYETTE HOWARD, B.Agr., B.S. (Univ. Mo., '01), M.S. (do., '03), Ph.D. (Univ. Halle-Wittenberg, '06); *University Farm, Davis, Calif.;* Assist. in Hort., Univ. Mo.; '01-'03; Instr., do., '03-'04; Asst. Prof., do., '05-'08; Sec., Mo. State Board Hort., '08-'12; Prof. Hort., Univ. Mo., '08-'15; Assoc. Prof. Pomology, Univ. of Calif., '15—.

1903—THOMAS FORSYTH HUNT, B.S. (Univ. Ill., '84), M.S. (do., '92), D.Agr. (do., '04), D.Sc. (Mich. Agr. Coll., '07); *Berkeley, Cal.;* Asst. State Ento. of Ill., '85-'87; Asst. Agr., Univ. of Ill., '86-'88; Asst. Agr. Ill. Expt. Sta., '88-'91; Prof. Agr., Pa. State Coll., '91-'92; Prof. Agr., Ohio State Univ., '92-'95; Dean Coll. Agr., Ohio State Univ., '95-'03; Prof. Agron., Cornell Univ., and Agron., Expt. Sta., '03-'06; Dean Coll. Agr. and Dir. Agr. Expt. Sta., Pa. State Coll., '06-'12; Dean Coll. Agr., Univ. Cal., and Dir. Expt. Sta., '12—.

1908—WILLIAM DANIEL HURD, B.S. (Mich. Agr. Coll, '99), M.Agr. (do., '08); *Chicago, Ill.;* Instr., Lansing High School, '99-'01; Prof. Hort., Briarcliff Agr. School, '01-'03; Prof. Agr., Univ. Me., '03-'05; Acting Dean, Coll. of Agr., do., '05-'06; Dean, '06-'09; Dir.

Ext. Service, Mass. Agr. Coll., '09-'17; Spec. Asst. to the Sec'y Agr., Wash., D. C., '17-'18 (Temp. leave of absence); Agronomist, Soil Imp. Com. Nat. Fert. Assn., Chicago, '19—.

1898—HENRY CLAY IRISH, B.S. (S. Dak. Agr. Coll., '91), M.S. (Iowa State Coll., '98); *Missouri Botanical Garden, St. Louis, Mo.;* Hort. Asst., Mo. Bot. Gard., '95-'02; Supt., do., '03-'12; Landscape Architect, '12-'13; Asst. Prof., Landscape Gard. and Flor., Iowa St. Coll., '13-'14; Supervisor, School Gardens, St. Louis, Mo., '14—.

1908—MEYER EDWARD JAFFA, Ph.B. (Univ. Cal., '77), M.S. (do., '96); *Berkeley, Cal.;* Asst. Chem., U. S. Census, '79-'80; Asst. Agr., Dept., Univ. Cal., '80-'81; Asst. Chem., Northern Transcontinental Surv., '81-'83; Asst. Chem., Univ. Cal., '83-'96; Asst. Prof. Agr., do., '96-'06; Nutr., '06-'08; Prof. Natr., do., '08—.

1885—EDWARD HOPKINS JENKINS, A.B. (Yale Univ., '72), Ph.D. (do., '79); *New Haven, Conn.;* Chem., Conn. Expt. Sta., '76-'00; Vice Dir., do., '82-'00; Dir., do., '00—; Treas., do., '01—; Dir. Storrs Expt. Sta., '12—.

1915—J. SHIRLEY JONES, B.S. (Univ. of Calif., '03); M.S. (Cornell Univ., '14); *Moscow, Idaho;* Asst. in Chem., Univ. of Calif., '02-'03; Asst. Chem. to Dr. H. E. Miller, San Francisco, '03-'04; Chem. for Giant Powder Co., San Jose, Calif., '05-'07; Chem. Idaho Expt. Sta. and Prof. Agr. Chem., Idaho St. Coll. of Agr., '07-'14; Dir. Idaho Expt. Sta., '14—.

1894—WHITMAN HOWARD JORDAN, B.S. (Univ. Me., '75), M.S. (do., '79), D.Sc (do., '96), LL.D (Mich. Agr. Coll., '07); *Geneva, N. Y.;* Asst. Chem., Conn Expt. Sta., '78-'79; Inst. Agr., Univ. Me., '79-'80; Prof. Agr. and Agr. Chem., Pa. State Coll., '81-'85; Dir. Me. Expt. Sta., '85-'96; Prof. Agr., Univ. Me., '94-'96; Dir., N. Y. Expt. Sta., '96—.

1912—JOHN CHESTER KENDALL, B.S. (N. H. Coll., '02); *Durham, N. H.;* Instr. in Dairy Husb., N. C. Agr. Coll., '02-'03; Asst. Prof. of Dairy Husb., do., '03-'06; State Dairy Comr., Kans., '06-'07; Prof. of Dairy Husb., Kans. Agr. Coll., '08-'10; Dir., N. H. Expt. Sta., '10—; Dir. Agr. Ext., '11—.

1916—ALVIN KEZER, B.Sc. (Univ. of Nebr., '04), M.A. (do., '06); Special Agent B. P. I., '04-'06; Assoc. and Prof. of Soils, Univ. of Nebr., '06-'09; Prof. Agronomy and Farm Manager, Colo. Agr. Coll., '09—.

1909—BENJAMIN WESLEY KILGORE, B.S. (Miss. Agr. Coll., '88), M.S. (do., '90); *Raleigh, N. C.;* Asst. Chem., Miss. Agr. Coll., '88-'89; do., N. C. Expt. Sta., '89-'97; Prof. Chem., Miss. Agr. Coll. and Agr. Expt. Sta., '97-'99; State Chem., N. C. ,'99—; Dir., N. C. Expt. Sta., '01-'07; do., '13—.

1911—HENRY GRANGER KNIGHT, A.B. (Univ. Wash., Seattle, '02), A.M. (do., '04); *Stillwater, Okla.;* Asst. Chem., Univ. Wash., '00-'01; Instr., do., '01-'02; Asst. Chem., Univ. Chicago, '02-'03; Asst. Prof. Chem., Univ. Wash., '03-'04; Prof. Chem., Univ. Wyo., and

State Chem., '04—; Dir., Wyo. Expt. Sta., '10-'18; Dean Coll. Agr., do., '12-'18; Dean Coll. Agr. and Dir. Expt. Sta., Okla. A. & M. Coll., '18—.

1916—E. J. KRAUSS, B.S. (Mich. Agr. Coll., '07); Ph.D. (Univ. of Chicago '17); U. S. D. A. Bur. Ent., '07-'09; Prof. Research in Hort., Ore. Agr. Expt. Sta., '09—.

1889—EDWIN FREEMONT LADD, B.Sc. (Univ. Me., '84), LL.D. (do., '17); *Agricultural College, N. Dak.;* Asst. Chem., N. Y. State Expt. Sta., '84-'87; Chief Chem., do., '87-'90; Prof. Chem., N. Dak. Agr. Coll. and Chem. Expt. Sta., '90—; Food Comr. and State Chem., N. Dak., '00—; Pres. N. D. Agr. Coll., '17—;

1899—JOSEPH BRIDGEO LINDSEY, B.Sc. (Mass. Agr. Coll., '83), Ph.D. (Univ. Gottingen, '92); *Amherst, Mass.;* Asst. Chem., Mass. State Expt. Sta., '83-'85; Commercial Chem., '85-'89; Assoc. Chem., Mass. State Expt. Sta., '92-'95; Head Dept. Foods and Feeding, Hatch Expt. Sta., '95-'07; Chem., Mass. Expt. Sta., '07—; Vice Dir., do., '09—; Head Dept. Chem., Mass. Agr. Coll. and Goessmann Prof. of Agr. Chem., '11—.

1911—FREDERICK BLOOMFIELD LINFIELD, B.S.A. (Ontario Agr. Coll., '91); *Bozeman, Mont.;* Asst. in Dairying, Ontario Agr. Coll., '92-'93; Prof. Anim. Industry. and Dairying, Utah Agr. Coll., '93-'02; Prof. Agr., Mont. Agr. Coll., '02—; Acting Dir., Mont. Expt. Sta., '03; Dir., do., '04—.

1912—CHARLES BERNARD LIPMAN, B.Sc. (Rutgers Coll., '04), M.Sc. (do., '09), M.S. (Univ. Wis., '09), Ph.D. (Univ. Cal., '10); *Berkeley, Cal.;* Instr. in Soil Bact., Univ. Cal., '09-'10; Asst. Prof. Soils, do., '10-'12; Assoc. Prof. of Soils, do., and Soil Chem. and Bact., Cal. Expt. Sta., '12-'13; Prof. of Soil Chem. and Bact. do., '13—.

1909—JACOB G. LIPMAN, B.Sc. (Rutgers, '98), A.M. (Cornell, '00), Ph.D. (do., '03); *New Brunswick, N. J.;* Asst. Chem., N. J. Expt. Sta., '98-'99; Fellow Chem., Cornell, '01; Soil Chem. and Bact., N. J. Expt. Sta., '01—; Asst. Prof. Agr., Rutgers, '06-'07; Assoc. do., '07-'10; Prof. Soil Chem. and Bact., '10—; Dir. N. J. Expt. Stas., '11—.

1911—CHARLES ALFRED LORY, B.Ped. (State Normal School, Greeley, Colo., '98), B.S. (Univ. Colo., '01), M.S. (do., '02), LL.D. (do., '09); *Fort Collins, Colo.;* Asst. in Physics, Univ. Colo., '99-'02; Prin. Cripple Creek High School, '02-'04; Acting Prof. Physics, Univ. Colo., '04-'05; Prof. Physics and Elect. Engin., Colo. Agr. Coll., '07-'09; Pres., do., '09—.

1911—ARTHUR GILLETT MCCALL, B.S. Agr. (Ohio State Univ., '00), Ph.D. (Johns Hopkins Univ., '16); *College Park, Md.;* Asst. Bur. Soils, U. S. Dept. Agr., '00-'04; Asst. Prof. Agron., Ohio State Univ., '04-'05; Assoc. Prof. Agron., do., '05-'06; Prof. Agron., do., '06-'16; in charge Soil Invest., Md. Expt. Sta., '16—.

1911—Charles Edward Marshall, Ph.B. (Univ. Mich., '95), Ph.D. (do., '02); *Amherst, Mass.;* Asst. Bact., Univ. Mich., '93-'96; do., Mich. Expt. Sta., '96-'98; Bact. and Hygienist, do., '98-'12; Sci. and Vice Dir., do., '08-'12; Prof. Bact. and Hyg., Mich. Agr. Coll., '03-'12; Dir. Graduate School and Prof. of Microbiol., Mass. Agr. Coll., '12—.

1911—Frederick Rupert Marshall, B.S.Agr. (Ontario Agr. Coll., '99), B.S.A. (Iowa State Coll., '00); *Washington, D. C.;* Asst. Prof. Anim. Husb., Iowa State Coll., '01-'03; Prof. Anim. Husb., Tex. Agr. Coll., '03-'07; Prof. Anim. Husb., Ohio State Univ., '07-'12; Prof. Anim. Indus., Univ. Cal., and Anim. Husb., Calif. Expt. Sta., '12-'13; Senior Anim. Husb., Bur. Anim. Indus., U. S. D. A., '13—.

1911—David William May, B.Agr. (Univ. Mo., '94), M. Agr. (do., '96); *Mayaguez, P. R.;* Asst. Agr., Missouri Expt. Sta., '97; Sci. Asst. Office Expt. Stas., U. S. D. A., '00-'02; Anim. Husb., Ky. Expt. Sta., '02-'04; Special Agt. in charge, P. R. Expt. Sta., '04—.

1905—Lucius Herbert Merrill, B.S. (Univ. Me., '83), D.Sc. (honorary do., '08); *Orono, Me.;* Chem., Me. Expt. Sta., '86-'08; Prof. Biol. Chem., Univ. Me., '98-'07; Prof. Biol. and Agr. Chem., do., '07—.

1909—Merritt Finley Miller, B.S.Agr. (Ohio State Univ., '00), M.S.A. (Cornell Univ., '01); *Columbia, Mo.;* Asst. Bur. Soils, U. S. Dept. Agr., '01-'02; Instr. Agron., Ohio State Univ., '02-'03; Asst. Prof., do., '03-'04; Prof. Agron., and Agron., Univ. Mo. and Expt. Sta., '04—.

1900—John Harcourt Alexander Morgan, B.S.A. (Univ. Toronto, '89); *Knoxville, Tenn.;* Prof. Ento. and Hort., La. State Univ., '89-'93; Prof. Zool. and Ento., do., '93-'04; Ento., La. Expt. Stas., '89-'04; Dir. Gulf Biol. Sta., '99-'05; Dir. Tenn. Expt. Sta., '05—.

1911—Fred Winslow Morse, B.S. (Worcester, '87), M.S. (do., '00); *Amherst, Mass.;* Asst. Chem., Mass. Expt. Sta., '87-'88; do., N. H. Expt. Sta., '88-'89; Chem., do., '89-'09; Vice Dir., do., '96-'09; Prof. Chem., N. H. Agr. Coll., '90-'09; Research Chem., Mass. Expt. Sta., '10—.

1912—Warner Jackson Morse, B.S. (Univ. Vt., '98), M.S. (do., '03), Ph.D. (Univ. Wis., '12); *Orono, Me.;* Teach. Nat. Sci., Montpelier Seminary, '99-'01; Asst. Bot., Vt. Expt. Sta., '01-'06; Instr. Bot., do., '01-'05; Asst. Prof. Bact., do., '05-'06; Plant Path., Me. Expt. Sta., '06—.

1916—George Edwin Morton, B.S. (Colo. Agr. Coll., '04), M.L. (Milton Coll., Wis., '04); Asst. and Prof. An. Husb., Univ. of Wyo., '04-'07; Prof. An. Husb., Colo. Agr. Coll., '07-'08; Head An. Husb. Dept., do., '08—; Colo. State Dairy Comnr., '13—.

1909—Frederick Blackmar Mumford, B.S. (Mich. Agr. Coll., '91), M.S. (do., '93); *Columbia, Mo.;* Asst. Mich. Expt. Sta., '91-'95; Asst. Prof. Agr., Mich. Agr. Coll., '93-'95; Prof. Agr., Univ. Mo., '95-'04;

Acting Dean Coll. Agr., Univ. Mo., and Acting Dir., Mo. Expt. Sta., '03-'05; Prof. Anim. Husb., Univ. Mo., '04—; in charge Anim. Husb. Dept., Mo. Expt. Sta., '06—; Dean Agr. and Dir. Expt. Sta., '09—.

1901—HERBERT WINDSOR MUMFORD, B.S. (Mich. Agr. Coll., '91); *Urbana, Ill.;* Instr., Mich. Agr. Coll., and Asst., Expt. Sta., '95-'96; Asst. Prof. Agr. and Anim. Husb., do., '96-'99; Prof. Agr., do., '99-'01; Prof. Anim. Husb., Univ. Ill., and Chief in Anim. Husb., Ill. Expt. Sta., '01—.

1913—MARTIN NELSON, B.S.A. (Univ. Wis., '05), M.S. (do., '06); *Fayetteville, Ark.;* Adj. Prof. Field Crops and Soils, Univ. Nebr. and Expt. Sta., '06-'07; Asst. Prof. do., '07-'08; Prof. Agron. and Agron., Univ. Ark. and Expt. Sta., '08-'13; Dean Univ. Ark. and Dir. Expt. Sta., '13—.

1893—HERBERT OSBORN, B.S. (Iowa State Coll., '79), M.S. (do., '80); *Columbus, Ohio;* Asst. Zool. and Ento., Iowa State Coll., '79-'83; Asst. Prof., do., '83-'85; Prof., do., '85-'98; Prof. Zool. and Ento., Ohio State Univ., '98—.

1893—LOUIS HERMAN PAMMEL, B.Agr., (Univ. Wis., '85), M.S. (do., '89), Ph.D. (Wash. Univ., '99); *Ames, Iowa;* Asst., Shaw School of Bot., '86-'89; Tex. Agr. Expt. Sta., '89; Prof. Bot., Iowa State Coll., '89—; Bot., Iowa Expt. Sta., '92—.

1893—HENRY JACOB PATTERSON, B.S. (Pa. State Coll., '86); *College Park, Md.;* Asst. Chem., Pa. Expt. Sta., '86-'88; Chem., Md. Expt. Sta., '88-'98; Dir. and Chem., do., '98—; Pres. Md. Agr. Coll., '13-'17.

1910—RAYMOND PEARL, A.B. (Dartmouth Coll., '99), Ph.D. (Univ. Mich., '02); *Orono, Me.;* Asst. Zool., Univ. Mich., '99-'02; Instr. Zool., do., '02-'06; Instr. Zool., Univ. Penn., '06-'07; Biol. and Head Dept. Biol., Me. Expt. Sta., '07—; Assoc. Ed., *Zool. Jahresber,* '06-'08; *Biometrika,* '06-'10; *Zentbl. Alig. u Expt. Biol.,* '10—.

1909—RAYMOND ALLEN PEARSON, B.S.A., (Cornell Univ., '94), M.S.A. (do., '99); *Ames, Iowa;* Asst. Chief Dairy Div., U. S. Dept. Agr., '95-'02; Mgr. Walker-Gordon Lab. Co., N. Y. and Phila., '02-'03; Prof. Dairy Ind., Cornell Univ., '03-'07; N. Y. Comr. Agr., '07-'12; Pres. Iowa State Coll., '12—.

1910—WILLIAM ROBERT PERKINS, B.S. (Miss. Agr. Coll., '91); M.S. (do., '94); *Baton Rouge, La.;* Asst. State Chem., Miss., '91-'94; Chem. Miss. Expt. Sta., '94-'06; Asst. Prof. Agr., Miss. Agr. Coll., '06; Agron., Miss. Expt. Sta., '07-'10; Dir. Agr. Dept., and Prof. Agron., Clemson Coll., '10-'11; Supt. Syndicate Farm, Deeson, Miss., '11—.

1909—CHARLES VANCOUVER PIPER, B.S. (Univ. Wash., '85), M.S. (do., '92; Harvard, '00); *Washington, D. C.;* Prof. Ento., Wash. State Coll., '92-'93; Prof. Bot. and Zool., do. and Bot. and Ento., Expt. Sta., '93-'03; Syst. Agrostrologist, U. S. Dept. Agr., '03-'04; Agrostologist, do., '05—.

1890—Charles Sumner Plumb, B.S. (Mass. Agr. Coll., '82); *Columbus, Ohio;* Asst. Ed. *Rural New Yorker,* '83-'84; First Asst., N. Y. Expt. Sta., '84-'87; Prof. Agr., Univ. Tenn., and Asst. Dir., Expt. Sta., '87-'90; Prof. Agr. Sci., Purdue Univ., '90-'94; Prof. Anim. Indus. and Dairying, do., '94-'00; Prof. Anim. Indus., do., '00-'02; Vice Dir., Ind. Expt. Sta., '90-'91; Dir., do., '91-'02; Prof. Anim. Indus., Ohio State Univ., '02—.

1894—Frank William Rane, B.Agr. (Ohio State Univ., '91), M.Sc. (Cornell Univ., 92); *State House, Boston, Mass.;* Hort. and Microscopist, W. Va. Expt. Sta., '92-'95; Prof. Agr. and Hort., W. Va. Univ., '93-'95; Prof. Agr. and Hort., N. H. Coll., '95-'98; Prof. Hort., do., '98-'00; Prof. Forestry and Hort., do., '00-'06; State Forester, Mass., '06—.

1913—James Burness Rather, B.S. (Tex. Agr. Coll., '07), M.S. (do., '11), A.M. (Johns Hopkins Univ., '15); *Fayetteville, Ark.;* Asst. State Chem. Tex., '07-'09; Asst. Chem., Tex. Expt. Sta., '08-'12; First Asst. Chem., do., '12-'14; Prof. Agr. Chem. and Chem. to Expt. Sta., Coll. of Agr., Univ. of Ark., '15—.

1913—George Matthew Reed, A.B. (Geneva Coll., '00), A.M. (Univ. Wis., '04), Ph.D. (do., '07); *Columbia, Mo.;* Prof. Nat. Sci. Amity Coll., '00-'03; Asst. in Bot., Univ. Wis., '04-'07; Instr. in Bot., do., '07; Asst. Prof. Bot., Univ. Mo., '07-'12; Prof. Bot., do., '12—; Bot., Mo. Expt. Sta., '09—.

1919—Wilfred William Robbins, A.B. (Univ. Colo., '07), A.M. (do., '09), Ph.D. (Univ. Chicago, '17); *Fort Collins, Colo.;* Instr. High Sch., Golden, Colo., '06-'07; Instr. Phys., Central High Sch., Pueblo, Colo., '07-'08; Instr. Biol., Univ. Colo., '08-'11; Instr. Biol., Summer Lab. for Field Biol., Tolland, '09, '10, '13; Instr. Bot., Colo. Agr. Coll., '11-'13; Asst. Prof., do., '13-'15; Prof. do., and Bot. Exp. Sta., '15—.

1881—Isaac Phillips Roberts, M.Agr. (Iowa State Coll., '75), 731 *Cameron Avenue, Fresno, Cal.;* Prof. Agr. and Dean Agr., Cornell Univ., '73-'94; Dir. Cornell Expt. Sta., '88-'03; Dir. Coll. Agr., '94-'03; Prof. Emeritus, lecturer and author, '03—.

1893—James Wilson Robertson, LL.D. (Toronto Univ. and Queen's Univ., '03; Univ. New Brunswick, '04); *Box* 540, *Ottawa, Can.;* Prof. Dairying, Ontario Agr. Coll., '86-'90; Dairy Comr. Canada, '90-'95; Comr. Agr. and Dairying, '95-'04; Prin., MacDonald Coll., '05-'09; Chairman Royal Com. on Indus. Training and Tech. Ed., '10—.

1909—Peter Henry Rolfs, B.S., M.S. (Iowa State Coll., '91); *Gainesville, Fla.;* Asst. Bot., Iowa State Coll., '91; Ento. and Bot., Fla. Expt. Sta., '92-'98; Bot. and Hort., do., '98-'99; Bot. and Bact., S. C. Expt. Sta., '99-'01; Plant Path. in charge Sub-Trop. Lab., U. S. Dept. Agr., Miami, Fla., '01-'06; Dir., Fla. Expt. Sta., '06—; State Supt. Farmers' Institutes, '07—.

1911—George McCullough Rommel, B.S. (Iowa Wesleyan Univ., '97), B.S.A. (Iowa State Coll., '99); *Washington, D. C.;* Expert in Anim. Husb., do., '05-'09; Chief, Anim. Husb. Div., do., '10—.

1909—HARRY LUMAN RUSSELL, B.S. (Univ. Wis., '88), M.S. (do., '90), Ph.D. (Johns Hopkins, '92); *Madison, Wis.;* Fellow, Univ. Wis., '88-'90; Fellow, Univ. Chicago, '92-'93; Asst. Prof. Bact., Univ. Wis., '93-'96; Prof., do., '96-'97; Bact., Wis. Expt. Sta., '93-'97; Dir. State Hygienic Lab., '03-'07; Dean Coll. of Agr. and Dir. Expt. Sta., Univ. Wis., '07—; Dir., Agr. Ext., '14—.

1912—WALTER GEORGE SACKETT, B.S. (Univ. Chicago, '02); *Fort Collins, Colo.;* Prof. Nat. Sci., Meredith Coll., '02-'04; Special Agt., U. S. Dept. Agr., '04; Instr. Bact. and Hyg., Mich. Agr. Coll., '04-'06; Asst. Prof. and Hyg., do., and Asst. Bact. Mich. Expt. Sta., '06-'08; Bact., Colo. Expt. Sta., '08—.

1908—EZRA DWIGHT SANDERSON, B.S. (Mich. Agr. Coll., '97), B.S. Agr. (Cornell, '98); *Ithaca, N. Y.;* Asst. State Ento. Md., '98-'99; Ento., Del. Expt. Sta., and Assoc. Prof. Zool., Del. Coll., '99-'02; State Ento., Tex., and Prof. Ento., Tex. A. and M. Coll., '02-'04; Ento., N. H. Expt. Sta., and Prof. Ento, and Zool., N. H. Coll., '04-'09; Dir. N. H. Expt. Sta., '07-'09; Dean Coll. Agr., W. Va. Univ., '10-'15; Dir., W. Va. Expt. Sta., '12-'15; Student, Univ. Chicago, '15-'18; Prof. Rural Organization, State Coll. Agr., Cornell Univ., '18—.

1910—ROBERT SIDNEY SHAW, B.S. (Ontario Agr. Coll., '93); *East Lansing, Mich;* Asst. Agr., Mont. Agr. Coll. and Expt. Sta., '97-'02; Prof. Agr., Mich. Agr. Coll., '02-'08; Dean Agr., do., and Dir. Exp. Sta., '08—.

1898—JOHN HENRY SHEPPERD, B.Agr. (Iowa State Coll., '91), M.S.A. (Univ. Wis., '93); *Agricultural College, N. Dak.;* Ed. Staff, *Orange Judd Farmer,* '93; Prof. Agr., N. Dak. Agr. Coll., and Agriculturist Expt. Sta., '93-'04; Dean and Vice Dir., '04—.

1909—JOHN HARRISON SKINNER, B.S. (Purdue Univ., '97); *Lafayette, Ind.;* Asst. Agr., Ind. Expt. Sta., '99-'01; Anim. Husb., Univ. Ill., '01-'02; Assoc. Prof. Anim. Husb., Purdue Univ., '02-'06; Prof., do., '06; Dean Agr. Dept., Purdue Univ., '07—.

1907—HOWARD REMUS SMITH, B.Sc. (Mich. Agr. Coll., '95); *Union Stock Yards, Chicago, Ill.;* Teacher, Tilford Collegiate Acad. and Rock Island High School, '95-'09; Acting Prof. Agr., Univ. Mo., '00-'01; Asst. Prof. Anim. Husb., Univ. Nebr., '01; Assoc. Prof., do., '02; Prof., do., '03-'12; Anim. Husb., Univ. Minn., '12-'15; Livestock Spec., Gr. Nor. Ry. and First Nat. Bank, St. Paul, Minn., '15-'17; Livestock Comr., Chicago Livestock Exch., '17—.

1899—HARRY SNYDER, B.S. (Cornell Univ., '89); 1800 *Summit Ave., Minneapolis, Minn.;* Asst. Chem., Cornell Univ. Expt. Sta., '90-'91; Asst. Instr. Qual. Anal., do., '89-'90; Prof. Agr. Chem., Univ. Minn., and Chem., Expt. Sta., '91-'09; Chem., Russell Miller Milling Co., '09—.

1909—ANDREW MCNAIRN SOULE, B.S. (Univ. Toronto, '93), Sc.D. (honorary, Univ. Ga., '10); *Athens, Ga.;* Asst. Dir. Mo. Expt. Sta., '94; Asst. Prof. Agr. and Asst. Agriculturist, Tex. Agr. Coll. and Expt. Sta., '94-'99; Dir. Tenn. Expt. Sta. and Chairman Agr. Faculty,

Univ. Tenn., '99-'04; Dean of Agr. and Dir. Expt. Sta., Va. Poly. Inst., '04-'07; Pres. Coll. Agr., Univ. Ga., '07—.

1903—WILLIAM JASPER SPILLMAN, B.S. (Univ. Mo., '86), M.S. (do., '89), Sc.D. (do., '10); *Philadelphia, Pa.;* Prof. Sci., Mo. State Normal, '87-'89; Prof. Sci., Vincennes Univ., '89-'91; Prof. Sci., Ore. State Normal, '91-'94; Prof. Agr., State Coll. Wash., '94-'01; Agrostologist, U. S. Dept. Agr., '01-'04; Agriculturist in charge Farm Management, do., '04-'18; Editor, *The Farm Journal,* '18—.

1911—FRANK LINCOLN STEVENS, B.L. (Hobart, '91), B.S. (Rutgers Coll., '93), M.S. (do., '97); Ph.D. (Univ. Chicago, '00), *Urbana, Ill.;* Teacher of Sci., Racine Coll., '93-'94; do., Columbus, O., High School, '94-'97; Instr. in Biol., N. C. Agr. Coll., '00-'02; Prof. Bot. and Veg. Path., do., '03-'11; Biol., N. C. Expt. Sta., '03-'11; Dean P. R. Coll. Agr., '12-'14; Prof. Plant Path., Univ. Ill., '14—.

1917—ROBERT STEWART, B.S. (Utah Agr. Coll., '02), Ph.D. (Univ. of Ill., '09); Prof. of Chem. and Asst. Dir. of Utah Agr. Expt. Sta., '08-'15; Assoc. Prof. Soils and Assoc. Chief in Soil Fertility, Expt. Sta., Univ. of Ill., '15—.

1908—WILLIAM ALTON TAYLOR, B.S. (Mich. Agr. Coll., '88), D.Sc. (do., '13); *Washington, D. C.;* Asst. Pomol., U. S. Dept. Agr., '91-'01; Pomol. in charge Field Investigations, '01-'10; Asst. Chief, Bur. Plant Indus., '11-'13; Chief, do., '13—.

1911—ROSCOE WILFRED THATCHER, B.Sc. (Univ. Nebr., '98), M.A. (do., '01); *University Farm, St. Paul, Minn.;* Asst. Chem., Nebr. Expt. Sta., '99-'01; Asst. Chem., Wash. Expt. Sta., '01-'03; Chem., do., '03-'12; Asst. Prof. Chem., State Coll. Wash., '04-'06; Assoc. Prof. do., '06-'10; Prof. Agr. Chem. and Head of Dept. Agr., do., '10-'13; Dir. Wash. Expt. Sta., '07-'13; Prof. Agr. Chem. and Agr. Chem., Univ. Minn. and Expt. Sta., '13-'17; Dean, Dept. Agr., Univ. of Minn. and Dir. Expt. Sta., '17—.

1907—CHARLES EMBREE THORNE, M.Agr. (Ohio State Univ., '90); *Wooster, Ohio;* Dir. Ohio Expt. Sta., '87—.

1910—EDWARD GAIGE TITUS, B.S. (Colo. Agr. Coll., '99); M.S. (do., '01), D.Sc. (Harvard, '11); *Logan, Utah;* Asst. Dept. Zool. and Ento., Colo. Agr. Coll., '00-'01; Field Asst. State Ento., Ill., '01-'03; Spec. Agt., Bur. Ento., U. S. Dept. Agr., '03-'07; Prof. Zool. and Ento., Utah Agr. Coll. and Ento. Expt. Sta., '07—.

1901—CHARLES ORRIN TOWNSEND, B.S. (Univ. Mich., '88), M.S. (do., '91), Ph.D. (Leipsic, '97); *Washington, D. C.;* Prof. St. Johns Coll., Md., '88-'91; Prof. Sci., Wesleyan Coll., Ga., '91-'95; Instr. Bot., Barnard Coll., '98; Prof. Bot., Md. Agr. Coll., and State Plant Path. Md., '98-'01; Path., Bur. Plant Indus., U. S. Dept. Agr., '01-'10; do., '12—; Consulting Agr., U. S. Sugar and Land Co., '10-'12.

1881—SAMUEL MILLS TRACY, B.A. (Mich. Agr. Coll., '68), M.S. (do., '76); *Biloxi, Miss.;* Asst. Prof. Agr., Mo. State Univ., '77-'80; Prof.

Bot. and Hort., do., '80-'87; Dir. Miss. Expt. Sta., '87-'97; Spec. Agt. U. S. Dept. Agr., '97—.

1894—WILLIAM TRELEASE, B.S. (Cornell, '80), D.Sc. (Harvard, '84), LL.D. (Wis., '02; Mo., '03; Wash. Univ., '07); *Urbana, Ill.;* Prof. Bot., Univ. Wis., '83-'85; Englemann Prof. Bot. and Dir. Shaw School Bot., Wash. Univ., '85—; Dir. Mo. Bot. Gard., '89-'12; Research Work, '10-'12; Prof. Bot., Univ. Ill., '13—.

1913—PERRY FOX TROWBRIDGE, B.Pd. (Mich. Norm. Coll., '92), Ph.B. (Univ. Mich., '92), A.M. (do., '05), Ph.D. (Univ. Ill., '06), M.Pd. (Mich. Norm. Coll., '11); *Fargo, N. D.;* Instr. Chem., Univ. Mich., '94-'02; Sugar Chem., do., '02-'05; Research Asst. and Instr. in Chem., Univ. Ill., '05-'07; Agr. Chem. and Assoc. Chem., Univ. Mo. and Expt. Sta., '07-'08; Prof. and Chem., do., '08-'18; Dir. N. D. Expt. Sta., '18—.

1907—ALFRED CHARLES TRUE, B.A. (Wesleyan Univ., Conn., '73), M.A. (do., '76), Ph.D. (Erskine Coll., S. C., '86), D.Sc. (Wesleyan Univ., '06); *Washington, D. C.;* Prin. High School, Essex, N. Y., '73-'75; Instr. State Normal School, Westfield, Mass., '75-'82; Grad. Stud., Harvard Univ., '82-'84; Instr., Wesleyan Univ., '84-'88; Ed., U. S. Office Expt. Stas., '88-'91; Asst. Dir., do., '91-'93; Dir., do., '93-'14; Dir., States Relations Service, U. S. D. A., '14—.

1914—HUBERT EVERETT VAN NORMAN, B.S. (Mich. Agr. Coll., '97); *Davis, Cal.;* Mgr. Dairy Farm, '97-'98; Supt. Univ. Farm, Purdue Univ., '98-'02; Chief, Dairy Dept., Purdue Univ., '02-'05; Prof. Dairy Husb., Pa. St. Coll., '05-'13; Prof. Dairy Mgmt., Univ. of Calif., '13—; Vice Dir., Agr. Expt. Sta. and Dean, Univ. Farm School, '13—.

1908—ALFRED VIVIAN, Ph.G. (Univ. Wis., '94); *Columbus, Ohio;* Instr. Phar., Univ. Wis., '94-'95; Asst. Agr. Chem., do., '95-'97; Instr., do., and Asst. Chem., Expt. Sta., '97-'02; Assoc. Prof. Agr. Chem., Ohio State Univ., '02-'05; Prof. Agr. Chem., do., '05—; Dean, Coll. Agr., do., '15—.

1912—JOHN FRANCIS VOORHEES, B.S.A. (Univ. Tenn., '09), M.S.A. (do., '11); *Knoxville, Tenn.;* Asst. Observ., U. S. Weather Bur., New Orleans, La., '01; do., Knoxville, Tenn., '02-'05; Observ. in charge Knoxville Sta., '06—; Instr. in Met. and Consult Met., Univ. Tenn. and Expt. Sta., '09—.

1893—HENRY JACKSON WATERS, B.Agr. (Univ. Mo., '86); *Manhattan, Kans.;* Asst. Agr., Mo. Expt. Sta., '87-'91; Prof. Pa. State Coll., '92-'95; Dean Coll. Agr. and Dir. Expt. Sta., Univ. Mo., '96-'09; Pres. Kans. State Agr. Coll., '09—.

1914—RALPH LEVI WATTS, B.A. (Pa. State Coll., '90), M.S. (do., '99); *State College, Pa.;* Hort. of Tenn. Expt. Sta., '90-'99; Lecturer, Farmers' Institutes, Pa., Md., N. J., '99-'08; Prof. of Hort., Pa. St. Coll., '08-'12; Acting Dean and Dir. School of Agr. and Expt. Sta., do., '12-'13; Dean and Dir., do., '13—.

1910—Herbert John Webber, B.Sc. (Univ. Nebr., '89); M.A. (do., '90), Ph.D (Wash. Univ., St. Louis, '00); *Riverside, Cal.;* Asst. in Bot., Univ. Nebr., '89-'90; Asst., Shaw School of Bot., '90-'92; Physiol., U. S. Dept. Agr., '92-'97; in charge Plant Breeding Lab., do., '97-'07; Prof. Expt. Plant Breeding, Cornell Univ., '07-'12; Dir., Citrus Expt. Sta., and Dean, Grad. School Trop. Agr., Univ. Cal., '13—.

1896—Julius Buell Weems, B.Sc. (Md. Agr. Coll., '88), Ph.D. (Clark Univ., '94); *South Boston, Va.;* Instr. Chem. and Math., Md. Agr. Coll., '88-'89; Con. Chem., do., '91-'92; Prof. Agr. Chem. and Chem. Expt. Sta., Iowa State Coll., '95-'04; Industrial Chem., '04—.

1904—Homer Jay Wheeler, B.Sc. (Mass. Agr. Coll. and Boston Univ., '83), Ph.D. (Univ. Gottingen, '89), D.Sc. (Brown, '11); 92 *State St., Boston, Mass.;* Asst. Chem., Mass. Expt. Sta., '83-'87; Chem., R. I. Expt. Sta., '89-'08; Prof. Geol., R. I. Coll., '89-'12; Prof. Agr. Chem., do., '03-'10; Acting Pres., do., '02-'03; Dir. Expt. Sta., do., '01-'12; Agron., do., '05-'12; Expert Amer. Agr. Chem. Co., '12—.

1889—Milton Whitney, *Washington, D. C.;* Asst. Chem., Conn. Expt. Sta., '83; Supt. Expt. Farm., N. C. Expt. Sta., '86-'88; Prof. Agr., S. C. Coll., and Vice Dir., Expt. Sta., '88-'91; Soil Physicist, Md. Expt. Sta., '91-'94; Prof. Soil Physics, Md. Agr. Coll., '94-'01; Chief Bur. Soils, U. S. Dept. Agr., '94—.

1898—John Charles Whitten, B.S. (S. Dak. Agr. Coll., '91), M.S. (do., '99), Ph.D. (Univ. Halle, '02); *Columbia, Mo.;* Instr. in Hort. and Hort. Expt. Sta., S. Dak. Agr. Coll., '92; Asst. in Hort., Mo. Bot. Gard., '93-'94; Prof. Hort. and Hort. Expt. Sta., Univ. Mo., '94—.

1911—John Andreas Widtsoe, B.S. (Harvard Univ., '94), Ph.D. (Univ. Gottingen, '99); *Logan, Utah;* Chem., Utah Expt. Sta., '94-'05; Prof. Chem., Utah Agr. Coll., '95-'05; Dir. Utah Expt. Sta., '00-'05; Dir. School of Agr., Brigham Young Univ., '05-'07; Pres., Utah Agr. Coll., '07—.

1919—Henry Jason Wilder, A.B. (Harvard '97); *Washington, D. C.;* Inst. Phys. and Chem., Dummer Acad., Mass., '97-'00; Soil Survey, U. S. D. A., '01-'06; Invest. Fruit Soils and Soils Mgt., '07-'14; Extens. Spec. Soils, States Rel. Service., N. and W., U. S. D. A., '14—.

1912—Julius Terrass Willard, B.S. (Kans. Agr. Coll., '83), M.S. (do., '86), D.Sc. (do., '08); *Manhattan, Kans.;* Asst. in Chem. Kans. Agr. Coll., '83-'87; Asst. Prof. Chem., do., '90-'96; Assoc. Prof. Chem., do., '96-'97; Prof. Appl. Chem., do., '97-'01; Prof. Chem., do., '01—; Dean, Div. Gen. Sci., do., '09—; Asst. Chem., Kans. Expt. Sta., '88-'97; Chem., do., '97—; Dir., do., '00-'06; Chem., Kans. Engin. Expt. Sta., '10—.

1912—CHARLES BURGESS WILLIAMS, B.S. (N. C. Agr. Coll., '93), M.S. (do., '96); *West Raleigh, N. C.;* Asst. Chem., N. C. Dept. Agr., '93-'06; Agron., do., '06-'07; Dir. and Agron., N. C. Expt. Sta., '07-'12; Vice Dir. and Agron., do., '13—.

1908—CARLOS GRANT WILLIAMS, *Wooster, Ohio;* Agron., Ohio Expt. Sta., '03—.

1911—WILLIAM ALPHONSO WITHERS, A.B. (Davidson Coll., '83), A.M. (do., '85); *West Raleigh, N. C.;* Grad. Stud. Cornell Univ., '88-'90; Fellow, do., '89-'90; Asst. Chem., N. C. Expt. Sta., '84-'88; Prof. Chem., N. C. Agr. Coll., '89—; Statis. Agt., U. S. Dept. Agr., '95-'02; Acting Dir., N. C. Expt. Sta., '97-'99; Chem., do., '97—.

1909—FRITZ WILHELM WOLL, B.S. (Royal Fredericks Univ., Christiania, '82), Ph.B. (do., '83), M.S. (Univ. Wis., '86), Ph.D. (do., '04); *Davis, Calif.;* Asst. Chem., Wis. Expt. Sta., '87-'97; Chem., do., '97-'13; Asst. Prof. Agr. Chem., Univ. Wis., '93-'04; Assoc. Prof., do., '04-'06; Prof., do., '06-'13; Prof. Anim. Nutr., Univ. Cal. and Expt. Sta., '13—.

1903—ALBERT FREDERICK WOODS, B.Sc. (Univ. Nebr., '90), A.M. (do., '92), D.Agr. (do., '13); *College Park, Md.;* Asst. Bot., Univ. Nebr., '91-'94; Asst. Chief Div. Veg. Path., U. S. Dept. Agr., '94-'00; Chief, do., '01-'09; Asst. Chief, Bur. Plant Indus., do., '01-'09; Dean Coll. of Agr., Univ. Minn., and Dir. Expt. Sta., '10-'17; Pres. Md. State Coll. Agr., '17—.

1903—CHARLES DAYTON WOODS, B.S. (Wesleyan Univ., Conn., '80), D.Sc. (honorary, Univ. Me., '05); *Orono, Me.;* Asst. Chem., Wesleyan Univ., '80-'85; Instr. Sci., Wilbraham Acad., Mass., '83-'88; Chem., Conn. Storrs Expt. Sta., '88-'96; Vice Dir., do., '89-'96; Prof. Agr., Univ. Me., '86-'03; Dir. Maine Expt. Sta., '96—.

1916—DANIEL WEBSTER WORKING, B.S. (Kans. State Agr. Coll., '88), M.S. Univ. of Denver, Colo., '07; *Tucson, Ariz.;* Lecturer, Colo. State Grange, '90-'91 and '94-'95; Master Colo. State Grange, '92-'93; Secy. Colo. State Board of Agr. and Agr. Coll., '93-'97; County Supt. Schools of Arapahoe County, Colo., '05-'07; Supt. Agr. Exten. Work, W. Va. Univ., '07-'11; Office Farm Mgmt. and Ext. Work in North and West, U. S. D. A., '11-'14; Agriculturist, Off. Extens. Work, N. & W., U. S. Dept. Agr., '14-'19; Dean and Dir., Univ. Ariz. Coll. Agr. and Agr. Expt. Sta., '19—.

1911—BONNEY YOUNGBLOOD, B.S. (Tex., Agr. Coll., '02), M.S. (do., '07); *College Station, Tex.;* Prin. and Instr. in Agr., Henderson, Tex., City Schools, '03-'05; Prin. and Inst. in Agr., Mineola, Tex., High School. '05-'06; Supt. City Schools and Instr. in Agr., Pauls Valley, Okla., '06-'07; Asst. Agr., Office of Farm Management, U. S. Dept. Agr., '07-'11; Dir., Tex. Expt. Sta., '11—.

1910—C. A. ZAVITZ, B.Sc. (Toronto Univ., '88); *Guelph, Canada;* Asst. Expt. Dept., Ontario Agr. Coll., '86-'93; Head of Expt. Dept., '93—; Prof. of Field Husbandry. Ontario Agr. Coll., '04—.

DECEASED MEMBERS

Robert Fairchild Kedzie............	Born	Dec. 9, 1852	Died	Feb. 13, 1882
Lauren Briggs Arnold.............	"	Aug. 13, 1814	"	Mar. 7, 1888
George Hammel Cook	"	Jan. 5, 1818	"	Sept. 22, 1889
Patrick Barry	"	May 24, 1816	"	June 24, 1890
John J. Thomas....................	"	Jan. 8, 1818	"	Feb. 22, 1895
Charles Valentine Riley	"	Sept. 18, 1843	"	Sept. 14, 1895
Charles Lee Ingersoll.............	"	Nov. 1, 1844	"	Dec. 15, 1895
Edward Louis Sturtevant	"	Jan. 23, 1842	"	July 30, 1898
Sir John B. Lawes, *Hon. Mem*......	"	Dec. 28, 1814	"	Aug. 31, 1900
John Alvah Myers..................	"	May 28, 1853	"	April 8, 1901
Sir Henry Gilbert, *Hon. Mem*........	"	Aug. 1, 1817	"	Dec. 23, 1901
Robert Clark Kedzie................	"	Jan. 28, 1883	"	Nov. 27, 1902
Victor Hunt Lowe..................	"	Sept. 23, 1869	"	Aug. 27, 1903
Henry English Alvord	"	Mar. 11, 1844	"	Oct. 1, 1905
Robert Warington, *Hon. Mem*......	"	Aug. 22, 1838	"	Mar. 20, 1907
Willis Grant Johnson..............	"	July 4, 1866	"	Mar. 11, 1908
James Fletcher	"	Mar. 28, 1852	"	Nov. 8, 1908
Samuel William Johnson............	"	July 3, 1830	"	July 21, 1909
William Henry Brewer..............	"	Sept. 14, 1828	"	Nov. 2, 1910
Charles Anthony Goessmann........	"	June 13, 1827	"	Sept. 1, 1910
Samuel B. Green....................	"	Sept. 15, 1859	"	July 11, 1910
Welton M. Munson.................	"	April 8, 1866	"	Sept. 9, 1910
Edward Burnett Voorhees..........	"	June 22, 1856	"	June 6, 1911
Franklin Hiram King..............	"	June 8, 1848	"	Aug. 4, 1911
Oskar Kellner, *Hon. Mem*..........	"	May 13, 1851	"	Sept. 22, 1911
John Bernhardt Smith..............	"	Nov. 21, 1858	"	Mar. 12, 1912
Melville Amasa Scovell..............	"	Feb. 26, 1855	"	Aug. 15, 1912
Charles Edwin Bessey..............	"	May 21, 1845	"	Feb. 25, 1915
Eugene Waldemar Hilgard..........	"	Jan. 5, 1833	"	Jan. 8, 1916
Joseph Hoeing Kastle..............	"	Jan. 25, 1864	"	Sept. 24, 1916
William Rane Lazenby..............	"	Dec. 5, 1850	"	Sept. 15, 1916
C. D. Smith.......................	"	Mar. 7, 1854	"	Aug. 1, 1916
Robert Hills Loughridge............	"	Oct. 9, 1843	"	July 1, 1917
Thomas Shaw......................	"	Jan. 3, 1843	"	June 24, 1918
Byron David Halsted..............	"	June 7, 1852	"	Aug. 28, 1918

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